(24,396)

SUPREME COURT OF THE UNITED STATES

OCTOBER TERM, 1915.

No. 259.

MINERALS SEPARATION, LIMITED, AND MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, PETITIONERS,

vs.

JAMES M. HYDE.

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE NINTH CIRCUIT.

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a United States Circuit Court of Appeals for the Ninth Circuit.

No. 2346.

TRANSCRIPT OF RECORD.

(In Three Volumes.)

JAMES M. HYDE, Appellant,

vs.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Appellees.

Upon Appeal from the United States District Court for the District of Montana.

1 [*Names and Addresses of*] *Attorneys of Record.*

Mr. Henry D. Williams, 76 Williams St., Bishop Bldg., New York.

Mr. Odell W. McConnell, Helena, Montana, Solicitors and of Counsel for Complainants and Appellees.

Messrs. Sheridan, Wilkinson, Scott and Richmond, Chicago, Illinois, and

Messrs. Kremer, Sanders and Kremer, Butte, Montana, Solicitors and of Counsel for Defendant and Appellant.

In the District Court of the United States in and for the District of Montana.

No. 1076.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION, AMERICAN SYNDICATE, LIMITED, Complainants,

vs.

JAMES M. HYDE, Defendant.

Be it remembered, that on the 3d day of October, 1911, a Bill of Complaint was filed herein, which said bill is in the words and figures as follows, to wit: (1*)

*Page number appearing at foot of page of original certified Record.

2 United States Circuit Court, District of Montana, Northern Division.

In Equity.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,
vs.
JAMES M. HYDE, Defendant.

Bill of Complaint.

To the Honorable Judges of the Circuit Court of the United States in and for the District of Montana, Northern Division:

Minerals Separation, Limited, a corporation duly organized and existing under and by virtue of the laws of Great Britain, and an inhabitant of Great Britain and having its principal office in London, England, and Minerals Separation American Syndicate, Limited, also a corporation duly organized and existing under the laws of Great Britain, and an inhabitant of Great Britain, also having its principal office in London, England, bring this their bill against James M. Hyde, of Basin, Jefferson County, State of Montana, a resident of the state of Montana and an inhabitant of the Northern Division of the District of Montana; and thereupon your orators complain and say: (2)

First. That heretofore and before the 29th day of May, 1905, Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-
3 Picard, and John Ballot, all of London, England, did invent and were the original, first and joint inventors of certain new and useful improvements in Ore Concentration fully described in the letters patent hereinafter mentioned, which invention had not been known or used in the United States before their invention or discovery thereof, or patented or described in any printed publication in any country before their invention or discovery thereof or more than two years prior to their application for letters patent of the United States hereinafter mentioned, or in public use or on sale in the United States for more than two years prior to their said application, and had not been patented in any country foreign to the United States on an application filed by them or their legal representatives or assigns more than twelve months prior to the filing of their said application for letters patent of the United States, and had not been abandoned to the public; that the said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot, being as aforesaid the joint inventors of the said invention, did on the 29th day of May, 1905, make due and formal application to the Commissioner of Patents of the United States for letters patent of the United States therefor, in accordance with the then existing laws of the United States, and duly complied in all respects with the conditions and requirements of said laws; and thereafter, after due proceedings had, on the

6th day of November, 1906, letters patent of the United States numbered 835,120, signed by the Assistant Secretary of the
4 Interior and countersigned by the Commissioner of Patents and sealed with the seal of the Patent Office, all in due form of the law and bearing date the day and year last aforesaid, were duly issued and delivered to the said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot, whereby was secured to them, their executors, administrators and assigns, for the term of seventeen years (3) from the 6th day of November, 1906, the full and exclusive right of making, using and selling the said improvements in Ore Concentration shown, described and claimed in said letters patent, throughout the United States and the territories thereof, which letters patent are now on record in the United States Patent Office, and which, or a duly certified copy thereof, your orators will produce as your Honors may direct.

Second. And your orators further show unto your Honors that on or about the 7th day of December, 1909, the said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot, by an instrument in writing duly executed and delivered by them and bearing date the last named day, assigned and transferred to your orator, Minerals Separation, Limited, all right, title and interest in and to the said invention and letters patent, and that the said instrument in writing was duly recorded in the Patent Office of the United States on or about the 28th day of August, 1911, all of which will more fully appear by the said instrument in writing with the certificate of the Commissioner of Patents ready in court to be produced as your Honors may direct.

5 Third. And your orators further show unto your Honors that on or about the 10th day of October, 1910, by an instrument in writing duly executed and delivered and bearing date the last named day, your orator, Minerals Separation, Limited, granted unto your orator, Minerals Separation American Syndicate, Limited, and your orator, Minerals Separation American Syndicate, Limited, received and accepted the sole and exclusive right, license, power and authority to apply, use and exercise in the United States of America the invention described in the said letters patent No. 835,120 for the term of two years from the said 10th day of October, 1910, together with the option to purchase said letters patent during said term of two years, all of which will more fully appear by the (4) said instrument in writing ready in court to be produced as your Honors may direct.

Fourth. And your orators further show unto your Honors that by virtue of the premises your orators became, and now are, the sole owners of all right, title and interest in and to the said letters patent and the said invention covered thereby, and all rights therein and thereunder within and throughout the United States, and your orators show that the rights and privileges secured by the said letters patent have been generally acquiesced in throughout the United States excepting in the instance of this defendant and his confederates, and that the said invention described in said letters patent

is of great value and utility to your orators and the public
6 generally, and that your orators have made the said invention profitable to themselves and to the public by careful and elaborate tests of said invention in its application to a wide variety of ores and by extensive commercial use of the said invention in different parts of the world, and by numerous demonstrations of the utility of said invention in the treatment of ores that are mined and treated in the United States, and that your orators have made and are making great efforts toward the introduction of said invention into extensive commercial use in the United States; and that your orators have invested large sums of money in said invention in the demonstrations thereof and the efforts to introduce the same into commercial use in the United States and in making the same valuable to the public and to themselves, and that your orators are able and willing to supply the entire demand for the use of the said invention throughout the United States, and that your orators will realize and receive large gains and profits from the said invention if infringement by the defendant and his confederates shall be prevented.

Fifth. And your orators further show unto your Honors that prior to the date of the infringement herein (5) complained of, the defendant, James M. Hyde, had been for a period of about one year in the employment of your orator, Minerals Separation, Limited, such employment having terminated on or about February 1, 1911; that the defendant, when thus employed, was instructed by the
7 engineers and experts of your said orator in all technical details and particulars as to the said letters patent No. 835,120, and the installation and use of the process of ore concentration constituting said invention; and your orators further show that the usual manner of conducting the business of using the said invention is the installation of proper apparatus and the granting of licenses for using said invention conditioned on the payment of royalties measured by the output of the said process of ore concentration.

Sixth. And your orators further show unto your Honors, that the defendant, well knowing the premises and the rights secured to your orators as aforesaid, and contriving to injure your orators and to deprive them of the benefits and advantages from said invention and letters patent, did, after the issuance of said letters patent and since the termination of the employment of the defendant by your orators, Minerals Separation, Limited, as aforesaid, and before the commencement of this suit, as your orators are informed and believe, without the license or allowance, and against the will of your orators, and in violation of their rights and in infringement of the aforesaid letters patent No. 835,120, unlawfully and wrongfully, and in defiance of the rights of your orators, at the town of Basin, in the County of Jefferson, State of Montana, and within the Northern Division of the District of Montana, where the defendant has a regular and established place of business, and elsewhere in the United States, install
8 apparatus for and carry on the use of the said process of ore concentration set forth and claimed in the aforesaid letters patent No. 835,120, and confederated with others in such in-

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stallation and use, and is threatening (6) to further induce others to make such installation and use, all in infringement of your orators' rights under the said letters patent whereby your orators have been and still are being deprived of great gains and profits that they might and otherwise would have obtained, and which have been realized and enjoyed by the said defendant by and through his aforesaid unlawful acts and doings.

Seventh. And your orators further show unto your Honors, on information and belief, that the said defendant has made and received, and is making and receiving large profits and advantages from the infringement of the said letters patent as aforesaid, but to what extent and how much exactly your orators do not know, and pray a discovery thereof.

Eighth. And your orators further show unto your Honors that the installation and use of the said invention by the said defendant and his other unlawful acts in this regard in defiance of the rights of your orators, have the effect of aiding, encouraging and inducing others so to venture to infringe said letters patent in disregard of your orators' rights.

Ninth. And your orators further show unto your Honors that they have caused notice to be given to the said defendant of the said infringement of the rights of your orators in the premises and have requested him to desist and refrain therefrom, but the said defendant has disregarded such notices and refuses to desist from
9 said infringement, and has continued after such notice in the infringement of your orators' rights as aforesaid.

And inasmuch as your orators cannot have any adequate relief except in this Court, and to the end that the defendant may, if he can, show cause why your orators should not have the relief herein prayed for, and may, but not upon oath (an oath to the defendant's answer being hereby waived) according to his best and utmost knowledge, (7) remembrance, information and belief, full, true, direct and perfect answers make to all and singular the premises and that the said defendant may be compelled to account for and pay to your orators the profits thus unlawfully derived, or which might have been derived from the violation of the rights of your orators as aforesaid, as well as the damages therefor, and be restrained from any further violation of said rights, your orators pray that your Honors may grant a writ of injunction restraining the defendant, his confederates, associates, servants, agents, attorneys, clerks and workmen, and every person acting for or on behalf of said defendant, from any installation or use in any manner of the said patented invention or any part thereof, in violation of the rights of your orators as aforesaid, and from encouraging and inducing others to infringe the said letters patent and from defending other infringers of said letters patent or reimbursing them the expense of defending against said letters patent in whole or in part, or otherwise aiding or abetting others to install or use processes of ore concentration in infringement
10 of said letters patent; and also that your Honors, upon the entering of a decree for infringement, as above prayed for,

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may proceed to assess or cause to be assessed, under your Honors' direction, in addition to the gains or profits to be accounted for by the defendant, the damages your orators have sustained by reason of said infringement, and that the amount of said damages may, in view of the wanton character of the infringement committed, be increased to a sum not exceeding three times the amount thereof.

And your orators pray also for a provisional or preliminary injunction during the pendency of this suit to the same purport and effect as hereinbefore prayed in regard to a perpetual injunction, and that the said defendant may be decreed to pay the costs of this suit; and for such further and other relief as the equity of the case may require, and as to your Honors may seem meet.

May it please your Honors to grant unto your orators (8) a writ of injunction conformable to the prayer of this bill, and also a writ of subpœna issuing out of and under the seal of this Honorable Court directed to the said defendant James M. Hyde commanding him by a certain day and under a certain penalty to appear before this Honorable Court, then and there to answer the premises, and to abide by and perform such orders and decrees in the premises as to the Court shall seem meet, and be required by the principles of equity and good conscience.

11 And your orators will ever pray, etc.

MINERALS SEPARATION, LTD.,
By S. GREGORY, *Director.*
MINERALS SEPARATION AMERICAN SYNDICATE, LTD.,
By S. GREGORY, *Director.*
McCONNELL & McCONNELL,
Solicitors for Complainants.

HENRY D. WILLIAMS,
Of Counsel.

UNITED STATES OF AMERICA,
State of New York, County of New York, ss:

Seth Gregory, being duly sworn, deposes and says that he is a director of Minerals Separation, Limited, one of the complainants named in the foregoing bill of complaint, and that he is also a director of Minerals Separation American Syndicate, Limited, the other complainant named in the foregoing bill of complaint; that he has read the same and knows the contents thereof, and that the same is true of his own knowledge, except as to the matters therein alleged on information and belief, and as to those matters he believes it to be true; and that he (9) verily believes that Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot were the true, first original and joint inventors of the invention set forth and claimed in the letters patent referred to in the bill of complaint.

SETH GREGORY.

12 Subscribed and sworn to before me this 29th day of September, 1911.

[SEAL.] BERNARD COWEN,
Notary Public, New York County.

Filed October 3, 1911. Geo. W. Sproule, Clerk.

And thereafter on Nov. 29, 1911, the answer of defendant was filed, being as follows, to wit: (10)

United States Circuit Court, District of Montana, Northern Division.

In Equity. No. 1076.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,
vs.
JAMES M. HYDE, Defendant.

Answer.

The Answer of James M. Hyde, Defendant, to the Bill of Complaint of the Complainant, Minerals Separation, Limited, and Minerals Separation American Syndicate, Limited.

This defendant, now and at all times saving and reserving unto *itself* all and all manner of benefit and advantage of exception which can or may be had or taken to the errors, uncertainties or other imperfections contained in the bill of complaint herein, for answer thereto, or so much or such parts thereof as *it* is advised it is
13 material to make answer unto, says as follows:

I.

This defendant is not informed, save by the bill of complaint, that the complainants, or either of them, are corporations organized or existing under or by virtue of the laws of Great Britain, or of any other country, State (11) or nation, or are inhabitants of Great Britain, or any other country, having their principal offices in London, England, or elsewhere, and therefore neither admits -or denies the same, but calls for strict proof thereof.

II.

This defendant admits that he is a resident of Basin, Jefferson County, State of Montana, and an inhabitant of the Northern Division of the District of Montana.

III.

This defendant, upon information and belief, denies that Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard, or John

Ballot did invent or were the original, first or joint inventors of any new or useful improvements in Ore Concentration described in the letters patent referred to in said bill of complaint; denies that the alleged invention set forth in the patent sued upon was not known or used in the United States before the alleged invention thereof by the patentees, said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot; denies that said alleged invention was not patented or described in any printed publication in any country before their alleged invention or discovery thereof or
14 more than two years prior to their application for letters patent of the United States therefor; denies that said alleged invention was not in public use or on sale in the United States for more than two years prior to their said application for patent, and had not been patented in any country foreign to the United States on an application filed by them or their legal representatives or assigns more than twelve months prior to the filing of their said application for letters patent of the United (12) States; and denies that said invention had not been abandoned to the public.

IV.

This defendant admits Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard, and John Ballot obtained letters patent of the United States No. 835,120, dated November 6, 1906, for alleged improvements in ore concentration; but this defendant denies that said patentees were the first or joint inventors or discoverers of said alleged improvements; and denies that the same involved any improvements in ore concentration; and denies that they made due or formal application to the Commissioner of Patents of the United States for letters patent of the United States therefor in accordance with the then existing laws of the United States; and denies that they duly complied in all respects with the conditions and requirements of said laws; and defendant is not informed, and has no knowledge, save by said bill of complaint, as to whether said letters patent No. 835,120 were signed by the Assistant Secretary of the Interior, and
15 countersigned by the Commissioner of Patents and sealed with the seal of the Patent Office in due form of law, and therefore denies the same, and denies that said letters patent secured to said patentees, their executors, administrators and legal representatives for the term of seventeen years from the 6th day of November, 1906, or any period, the full, exclusive, or any right of making, using and selling the alleged improvement in ore concentration alleged to be shown, described and claimed in said letters patent, throughout the United States and the territories thereof; and this defendant is not informed, and has no knowledge, save by said bill of complaint, that said letters patent are now on record in the (13) United States Patent Office, and calls for strict proof of the same.

V.

This defendant is not informed, and has no knowledge, save by said bill of complaint, that on or about the 7th day of December,

1909, or at any other time, the said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot, by an instrument in writing, duly, or at all, executed or delivered by them and bearing date of the last-named day, or any date whatsoever, assigned and transferred to the complainant, Minerals Separation, Limited, all, or any, right, title or interest in or to the said letters patent and invention, or that the said instrument in writing was duly, or at all, recorded in the Patent Office of the United States on or about the 28th day of August, 1911, or at any other time, and therefore denies the same.

16

VI.

This defendant is not informed, and has no knowledge, recollection or belief, save by bill of complaint, that on or about the 10th day of October, 1910, or at any other time, said complainant, Minerals Separation, Limited, by an instrument in writing duly, or at all, executed, or delivered, or bearing date of the last-named day, or any date whatsoever, granted unto said complainant, Minerals Separation American Syndicate, Limited, or that said Minerals Separation American Syndicate, Limited, received or accepted the sole, exclusive, or any right, license, power or authority to apply, use or exercise in the United States of America the alleged invention described in said letters patent No. 835,120, for the (14) term of two years, or any other time, from the said 10th day of October, 1910, or from any other date, together with the option to purchase said letters patent during said term of two years, or any other term, or at all, and therefore denies the same.

VII.

This defendant is not informed, and has no knowledge, recollection or belief, save by said bill of complaint, that the said complainants became or now are the sole owners of all, or any right, title or interest in or to the said letters patent or the said alleged inventions covered thereby, or any or all rights therein or thereunder within or throughout the United States, and therefore denies the same (and this defendant denies the same); and this defendant denies that the alleged rights or privileges alleged to be secured by the said

17 letters patent have been generally, or at all, acquiesced in throughout the United States, or any part thereof, and denies that the said alleged invention described in said letters patent is of great, or any value, or utility to the complainants herein or to the public generally, or at all, and this defendant denies that the complainants herein have made the said alleged invention profitable to themselves or to the public by careful, elaborate, or any, tests of said invention in its application to a wide, or any, variety of ores, or by extensive, or any, commercial use of the said alleged invention in different, or any, parts of the world, or by numerous, or any, demonstrations of the utility of said invention in the treatment of ores that are mined or treated in the United States, or elsewhere; and denies that the complainants have made, or that they are making, great, or

any, efforts toward the introduction of said alleged invention into commercial, or any, use (15) in the United States; and this defendant denies that the complainants have invested large sums of money, or any sums of money, in said alleged invention in the demonstration thereof or the efforts to introduce the same into use in the United States, or in making the same valuable to the public or to themselves; and this defendant denies that complainants will realize or receive large gains and profits, or any gains and profits, from the said alleged invention if this defendant shall be restrained from practicing said alleged invention.

VIII.

This defendant admits that he was for a period of about
18 one year in the employ of the complainant, Minerals Separation, Limited, such employment having terminated on or about February 1, 1911, but this defendant denies that when thus employed he was instructed by the engineers or experts of the complainant in all or any of the technical details or particulars as to the said letters patent No. 835,120, or the installation or use of the process of ore concentration constituting said alleged invention; and avers that while in the employ of said complainant, Minerals Separation, Limited, as aforesaid, he was instructed in the practice and operation of certain processes which had been invented and discovered long prior to the alleged invention by said patentees of the process set forth in their said patent, and further avers that while he was in the employ of said complainant, Minerals Separation, Limited, he had no knowledge of said United States letters patent No. 835,120, was not instructed regarding the application or use of the process set forth in said patent, never saw said process in operation, and received no information, knowledge, or instruction from said complainant, Minerals Separation, Limited, other (16) than information, knowledge and instruction regarding matters known to the public long prior to the said alleged invention of said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard, and John Ballot, or their application *of* letters patent of the United States therefor.

IX.

This defendant denies that well knowing, or knowing at all, the alleged rights secured to said complainants, or contriving
19 to injure said complainants or to deprive them of the benefits or advantages from said alleged invention and letters patent, he did after the issuance of said letters patent, or at any other time, in violation of any of the rights of said complainants or in infringement of said letters patent No. 835,120, or in defiance of any rights of said complainants at the town of Basin, in the County of Jefferson, State of Montana, or elsewhere, install any apparatus for or carry on the use of the process of ore concentration set forth and claimed in the aforesaid letters patent No. 835,120, and denies that he confederated with others, or confederated at all, in such installation or use, or is threatening to further induce others to make

such installation or use in infringement of complainants' alleged rights under the said letters patent; and this defendant denies that said complainants have been, or still are, deprived of great gains and profits, or of any gains and profits, that they might or would have otherwise obtained, and further denies that such alleged profits of which complainants have been deprived have been realized or enjoyed by this defendant by or through unlawful acts or doings; and this defendant admits that he has installed an apparatus and operated a process at the town of Basin, Montana, for the concentration of (17) ores, but avers that said apparatus and process consist in the use of certain principles and machines which were invented and discovered long prior to the said alleged invention of said patentees, and further consists in certain apparatus and operations invented and discovered by this defendant, and further avers that the process practiced by him in the said town
20 of Basin, Montana, does not infringe said letters patent, does not utilize any information conveyed by said letters patent, and consists solely in the application of principles which were either discovered by said defendant or were the property of the public in the United States.

X.

This defendant denies that he has made and received, or is making and receiving, large, or any, profits, or advantages from the infringement of the said letters patent.

XI.

And this defendant denies that he has installed or used the said alleged invention set forth in said letters patent, or that he has committed any other unlawful act in this regard in defiance of the rights of the complainants, and further denies that he has committed any acts whatever which have had the effect of aiding, encouraging or inducing others to infringe said letters patent in disregard of the complainant's rights.

XII.

This defendant denies that the complainants have caused any notice to be given to him of the alleged infringement of the alleged rights of complainants in the (18) premises, or that the complainants have requested him to desist or refrain therefrom, and this defendant denies that he has disregarded any such notices, or that he has refused to desist from infringement of said letters patent, or has continued such infringement after such notice of complainants' alleged rights, or at any other time.

21 XIII.

This defendant further says that said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard, and John Ballot were not the original first or true inventors of the alleged invention in ore concentration, which said letters patent No. 835,120 purport to

embrace, or of any material or substantial part thereof; but that, on the contrary, said alleged invention, and all material and substantial parts had before their alleged invention been fully and clearly described or claimed in the following mentioned letters patent.

Letters Patent of the United States.

348,157, August 24, 1886, C. J. Everson.
466,753, January 5, 1892, E. A. Hockley.
469,599, February 23, 1892, A. M. Rouse.
653,340, July 10, 1900, F. E. Elmore.
676,679, June 18, 1901, F. E. Elmore.
689,070, December 17, 1901, A. S. Elmore.
692,643, February 4, 1902, A. S. Elmore.
735,071, August 4, 1903, G. D. Delprat.
736,381, August 18, 1903, M. F. R. Glogner.
745,960, December 1, 1903, I. F. Good.
768,035, August 23, 1904, G. D. Delprat.
771,075, September 27, 1904, C. Kendall.
776,145, November 29, 1904, C. V. Potter. (197.)

Letters Patent of Great Britain.

488, February 23, 1860, W. Haynes.
12,778, June 5, 1902, Lake (Froment).

22 Also patented or described and contained in other letters patent, the dates, numbers and grantees of which this defendant is not now able to specify, but prays to be allowed hereafter to add by amendment of this answer or otherwise, if it shall become necessary.

Also illustrated and described in printed publications, the names and dates of which defendant is not able to specify, but prays to be allowed hereafter to add to this answer by amendment or otherwise, if it shall become necessary.

XIV.

This defendant avers that for the purpose of deceiving the public the description and specifications filed by the said patentees in the Patent Office was made to contain more than the whole truth relative to their alleged invention or discovery, and more than is necessary to produce the desired effect.

XV.

This defendant avers that the said patentees were not the original and first inventors or discoverers of any material and substantial part of the thing patented, but that, on the contrary, the process which their said patent purports to embrace was known and used by Edmund B. Kirby, of Rossland, British Columbia, Canada, long

prior to the alleged invention and discovery thereof by said patentees, and that said Edmund B. Kirby introduced knowledge of said process into the United States in the month of December, 1903, by filing applications in the (20) United States Patent Office for patents, upon which applications letters patent Nos. 809,959
23 and 838,626 were granted on January 16, 1906, and December 18, 1906, respectively.

XVI.

This defendant says that the said patentees, Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot have admitted that the alleged invention which said letters patent No. 835,120 purport to embrace, and each and every material and substantial part thereof was old and known to others prior to their alleged invention and discovery thereof, and that said patentees made said admissions in the following described letters patent:

Letters Patent of the United States.

793,808, Sulman & Kirkpatrick-Picard, application filed October 5, 1903, patented July 4, 1905.

835,479, Sulman, Kirkpatrick-Picard & Ballot, application filed May 29, 1905, patented November 6, 1906.

879,985, Sulman, Kirkpatrick-Picard & Ballot, application filed February 20, 1905, patented February 25, 1908.

Letters Patent of Great Britain.

17,109, August 6, 1903, Cattermole, Sulman & Kirkpatrick-Picard.

20,419, September 22, 1903, Sulman & Kirkpatrick-Picard.

5,260, March 13, 1905, Sulman, Kirkpatrick-Picard & Ballot.

19,709, September 29, 1905, Sulman.

26,712, December 21, 1905, Sulman, Kirkpatrick-Picard & Ballot. (21)

XVII.

24 Defendant, further answering, says that the complainants herein are not entitled to the relief prayed for in their bill of complaint, without this that there is any other matter, cause or thing in the said bill of complaint contained, material or necessary for this defendant to make answer unto, and not hereinbefore sufficiently answered, confessed or avoided, traversed, or denied, is true; all of which this defendant is ready to aver, maintain and prove as this Honorable Court shall direct, and prays to be hence dismissed with his costs in this behalf most wrongfully sustained.

KREMER, SANDERS & KREMER,
Solicitors for Defendant.
SHERIDAN, WILKINSON, SCOTT & RICHMOND, *of Counsel.*

Filed Nov. 29, 1911. Geo. W. Sproule, Clerk.

And thereafter on December 30, 1911, Replication was filed herein, being as follows, to wit: (22)

In the United States Circuit Court, Ninth Circuit, District of Montana.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,
vs.
JAMES M. HYDE, Defendant.

25 *Replication.*

The Replication of the Above-named Complainants to the Answer of the Above-named Defendants.

These replicants, saving and reserving to themselves all and all manner of advantage of exception which may be had and taken to the manifold errors, uncertainties and insufficiencies of the answer of said defendant, for reply thereunto say that they do and will ever maintain and prove their said bill to be true, certain and sufficient in the law to be answered unto by said defendant, and that the answer of the said defendant is very uncertain, evasive and insufficient in the law to be replied unto by these replicants without that, that any other matter or thing in the said answer contained material or effectual in the law to be replied unto, and not herein and hereby well and sufficiently replied unto, confessed or avoided, traversed or denied is true; all of which matters and things these replicants are ready to aver, maintain and prove as this Honorable Court shall direct, and humbly as in and by their said bill they have already prayed.

O. W. McCONNELL,
Solicitors for Complainants.
HENRY D. WILLIAMS,
Of Counsel.

Service of above replication and receipt of copy accepted Dec. 29, 1911.

KREMER-SANDERS-KREMER,
Solicitors for Defendant.

26 Filed December 30, 1911. Geo. W. Sproule, Clerk. (23)

And thereafter on July 10, 1912, Amendment to Answer was filed herein as follows, to wit:

United States District Court, District of Montana.

In Equity. No. 1076.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,
vs.
JAMES M. HYDE, Defendant.

Amendment to Answer.

Now comes the defendant, James M. Hyde, and amends his answer in the above-entitled suit in the following manner, to wit:

By canceling that part of his answer following the numeral XIII and extending from and including the twenty-third line of page 9 of said answer through and including the twenty-second line of page 10, and substituting therefor the following:

"This defendant further says that said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot were not the original first or true inventors of the alleged invention in ore concentration which said letters patent No. 835,120 purport to embrace, or of any material or substantial part thereof, but that, on the contrary, said alleged invention and all material and
27 substantial parts thereof had before their alleged invention been fully and clearly described or claimed in the following mentioned letters patent: (24)

Letters Patent of the United States.

345, 951, July 20, 1886, H. Bradford.
348,157, August 24, 1886, C. J. Everson.
466,753, January 5, 1892, E. A. Hockley.
469,599, February 23, 1892, A. M. Rouse.
471,174, March 22, 1892, C. B. Hebron and C. J. Everson.
653,340, July 10, 1900, F. E. Elmore.
676,679, June 18, 1901, F. E. Elmore.
689,070, December 17, 1901, A. S. Elmore.
692,643, February 4, 1902, A. S. Elmore.
729,805, June 2, 1903, J. and L. Stoveken.
735,071, August 4, 1903, G. D. Delprat.
736,381, August 18, 1903, M. F. R. Glogner.
745,960, December 1, 1903, I. F. Good.
768,035, August 23, 1904, G. D. Delprat.
771,075, September 27, 1904, C. Kendall.
776,145, November 29, 1904, C. V. Potter.
777,273, December 13, 1904, A. E. Cattermole.
777,274, December 13, 1904, A. E. Cattermole, H. L. Sulman and H. F. Kirkpatrick-Picard.
788,247, April 25, 1905, A. E. Cattermole, H. L. Sulman and H. F. Kirkpatrick-Picard.
793,808, July 4, 1905, Sulman and H. F. Kirkpatrick-Picard.
809,959, January 16, 1906, E. B. Kirby.

28 Letters Patent of Great Britain.

488, February 23, 1860, W. Haynes.
12,778, June 4, 1902, Lake (Froment). (25)

Also that prior to the supposed invention or discovery of the alleged process patented in said letters patent No. 835,120 by said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot each and every material and substantial part of said supposed invention or discovery so patented had been invented and used by and was known to the following named persons, and was fully described in applications for letters patent of the United States deposited and filed by said persons in the United States Patent Office prior to the supposed invention or discovery of said alleged process set forth in said letters patent No. 835,120 by said Sulman, Kirkpatrick-Picard and Ballot; that said applications were so deposited and filed in the United States Patent Office and that letters patent of the United States were granted upon said applications as set forth below:

Moritz F. R. Glogner, a resident of Freiburg, in the Kingdom of Prussia, German Empire, on January 27, 1903, deposited and filed in the United States Patent Office his application for letters patent of the United States, and that letters patent No. 736,381 were granted thereon upon August 18, 1903.

Israel F. Good, a resident of Allentown, Pennsylvania, on October 1, 1902, deposited and filed in the United States Patent Office his application for letters patent of the United States, and
29 that letters patent No. 745,960 were granted thereon upon December 1, 1903.

Guillaume D. Delprat, a resident of Broken Hill, Australia, on January 2, 1903, deposited and filed in the United States Patent Office his application for letters patent of the United States, and that letters patent No. 768,035 were granted thereon upon August 23, 1904.

Cosmo Kendall, a resident of Upper Norwood, Surrey, England, on July 21, 1903, deposited and filed in the (26) United States Patent Office his application for letters patent of the United States, and that letters patent No. 771,075 were granted thereon upon September 27, 1904.

Charles V. Potter, a resident of Balaclava, Victoria, Australia, on January 14, 1902, deposited and filed in the United States Patent Office his application for letters patent of the United States, and that letters patent No. 776,145 were granted thereon upon November 29, 1904.

Arthur E. Cattermole, a resident of Highgate, London, England, on September 28, 1903, deposited and filed in the United States Patent Office his application for letters patent of the United States, and that letters patent No. 777,273 were granted thereon upon December 13, 1904.

Arthur E. Cattermole, Henry L. Sulman and Hugh F. Kirkpatrick-Picard, all residents of London, England, on March 29, 1904,

deposited and filed in the United States Patent Office their application for letters patent of the United States, and that letters patent No. 777,274 were granted thereon upon December 13, 1904.

30 Arthur E. Cattermole, Henry L. Sulman and Hugh F. Kirkpatrick-Picard, all residents of London, England, on March 23, 1904, deposited and filed in the United States Patent Office their application for letters patent of the United States, and that letters patent No. 788,247 were granted thereon upon April 25, 1905.

Henry L. Sulman and [illegible] F. Kirkpatrick-Picard, residents of London, England, on October 5, 1903, deposited and filed in the United States Patent Office their application for letters patent of the United States, and that letters patent No. 793,808 were granted thereon upon July 4, 1905. (27)

Alfred Schwarz, a resident of New York City, New York, on April 19, 1905, deposited and filed in the United States Patent Office his application for letters patent of the United States, and that letters patent No. 807,501 were granted thereon upon December 19, 1905.

Alfred Schwarz, a resident of New York City, New York, on May 27, 1904, deposited and filed in the United States Patent Office his application for letters patent of the United States, and that letters patent No. 807,503 were granted thereon upon December 19, 1905.

Edmund B. Kirby, a resident of Rossland, Canada, on December 14, 1903, deposited and filed in the United States Patent Office his application for letters patent of the United States, and that letters patent No. 809,959 were granted thereon upon January 16, 1906.

Edmund B. Kirby, a resident of Rossland, Canada, on De-

31 cember 17, 1903, deposited and filed in the United States Patent Office his application for letters patent of the United States, and that letters patent No. 838,626 were granted thereon upon December 18, 1906."

By canceling that part of the answer following the numeral XVI and extending from and including the twenty-ninth line of page 11 of said answer through and including the twenty-second line of the twelfth page thereof, and substituting therefor the following:

This defendant says that the said patentees, Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot have admitted that the alleged invention which said letters patent No. 835,120 purport to embrace and each and every material and substantial part (28) thereof was old and known to others prior to their alleged invention and discovery thereof, and have stated that said alleged invention was the invention of others, and that said patentees made said admissions and statements in the following described letters patent, and in the applications therefor and proceedings in the United States Patent Office relating thereto.

Letters Patent of the United States.

793,808, Sulman & Kirkpatrick-Picard, application filed October 5, 1903, patented July 4, 1905.

835,143, Henry L. Sulman, application filed October 20, 1905, patented November 6, 1906.

835,479, Sulman, Kirkpatrick-Picard & Ballot, application filed May 29, 1905, patented November 6, 1906.
879,985, Sulman, Kirkpatrick-Picard & Ballot, application filed February 20, 1905, patented February 25, 1908.

32 Letters Patent of Great Britain.

17,109, August 6, 1903, Cattermole, Sulman & Kirkpatrick-Picard.
20,419, September 22, 1903, Sulman & Kirkpatrick Picard.
5,260, March 13, 1905, Sulman, Kirkpatrick-Picard & Ballot.
19,709, September 19, 1905, Sulman.
26,712, December 21, 1905, Sulman, Kirkpatrick-Picard & Ballot.

KREMER, SANDERS & KREMER,
Solicitors for Defendant.
SHERIDAN, WILKINSON, SCOTT & RICHMOND,
Of Counsel. (29)

It is stipulated that the foregoing amendment to the answer of defendant may be entered, provided, however, that should defendant prevail upon any of the matters set up in said amendment and not set up in his original answer, he may not recover costs for any proceedings prior to the deposition of the witness Eugene A. Byrnes.

McCONNELL & McCONNELL,
Solicitors for Complainant.
HENRY D. WILLIAMS,
Of Counsel.
KREMER, SANDERS & KREMER,
Solicitors for Defendant.
SHERIDAN, WILKINSON, SCOTT & RICHMOND,
Of Counsel.

33 Filed July 10, 1912. Geo. W. Sproule, Clerk. (30)

And on July 28, 1913, the opinion of the Court was filed herein as follows, to wit:

United States District Court, Montana.

MINERALS SEPARATION, LIMITED, et al.,
vs.
JAMES M. HYDE.

Opinion.

Complainants are owner- and its licensee of United States patent No. 835,120, for improvements in a process of ore concentration, issued on an application filed May 29, 1905, by said owner's grantors, Messrs. Sulman, Picard, and Ballot, of London, England, joint inventors and patentees, and this suit is for infringement of certain

claims of said patent by defendant, a former employee of said owner, and by it trained in the process. The defenses are various grounds of invalidity hereinafter noted so far as of merit and seriously urged, and noninfringement.

The invention claimed, in general terms, may be said to be the discovery in March, 1905, that if a very small and appropriate quantity of an oily substance, ranging around .02% to .5% of the weight of the ore be added to a pulp of water and finely pulverized ore (the slimes being helpful and most easily recovered) and the whole vigorously agitated and thereby thoroughly aerated by great and excess quantities of air, the metalliferous particles are oiled and adhere in a complete envelope to or of bubbles of the air and
34 rise to the surface of the mixture on cessation of agitation, forming a strong, coherent and stable froth easily removed. The process may be aided by heat to more quickly and effectively disseminate the oily substance through the pulp and bring it into contact with the metalliferous particles, and may also be aided by a mineral acid or salt up to 1% thereof of the weight of the ore to increase the preferential affinity of the oil for metal over (31) gangue, but not sufficient acid to cause chemical action on the metal, nor is it intended to generate gas for flotation. The patent specification is full, complete and clear to those skilled in the art, and describes one well-known apparatus of mixing vessels, spitzkasten, etc., and the operation of the process therewith.

The claims are general and particular, all calling for oil and agitation to produce a froth, some defining a range of quantities of oily substance, some likewise of acid, some specifying oily substance alone, some oily substances in various combinations with heat or acid and with both. The main defense of invalidity is lack of novelty and anticipation. In reference thereto it appears from the evidence that the use of oil, air and agitation in ore concentration, separately and in various combinations, and with other ingredients, was well known to the art prior to the discovery of the process in suit. To briefly summarize the prior processes, some of them were bulk oil processes, using oil in such large quantities that in taking up the metalliferous particles in the pulp the mass thereof was yet sufficiently buoyant to float to the surface of water, the
35 gangue sinking. Concentration being more essential for lean ores, economy is the foundation of success; so other of these processes reduced the amount of oil to a degree where it was not sufficient of itself to float the metal, and to aid therein air, steam or gas was injected to render the mass spongy. Another process further reduced the oil and to and around 4% to 6% in weight of the metalliferous content of the ore, the somewhat novel result being that the metalliferous particles were by the oil agglomerated into granules which sank in the water and were retained in the mixing vessel, while the gangue rose and was carried off by upcast. Some dispensed with oil and employed surface tension or skin flotation by floating off the powdered (32) metalliferous particles on the surface of quietly flowing waters, or by injecting air, steam or gas into the mixture of ore and water, or by generating gas therein, whereby bubbles attached

to said particles and carried them to the surface of the water, in all the gangue sinking. Another process sought the same end by spraying the oiled metalliferous particles through air and onto water, where they remained, the gangue sinking. In some processes acid was used to generate gas in situ for flotation, while in others it was used solely to render more pronounced the selective attribute of oil for metal over gangue. This last feature was the discovery, so far as ore concentration is concerned, of Carrie J. Everson, of Chicago, to whom a domestic patent, embodying it, issued in 1886. In some heat was used to hasten the action of the oil, and some resorted to agitation.

36 For anticipation, defendant relies most upon Froment's patents and working description. They date from 1902 to 1903. The process thereof is one wherein the ore is carefully crushed in two operations so as to minimize slimes, and is first deslimed, for that the slime is "too fine to be treated," quoting Froment. Thereupon, to a mixture of deslimed ore and water oil and carbonate of lime (which may be limestone) are added proportionate to the weight and richness of the ore from 1% of oil in weight of the ore for ore containing up to 5% of metal, to 3½% of oil for ore containing 50% of metal, and from about 1% of carbonate of lime in weight of the ore, 2½% in difficult cases, or more, and in like proportions to the oil for richer ore, it requiring more gas. Agitation in mixture containing two stirrers revolving in opposite directions and for a few minutes, or about 10 minutes, at about 300 revolutions per minute, the "chief point" being that all metallic particles are brought "into thorough contact with the oil," is described by Froment. The mixture is then discharged into a vat containing a perforated coil through which sulphuric acid is introduced and in (33) quantity about *cent* per cent of the carbonate of lime, and a rake therein turns slowly and about 10 to 12 revolutions per minute to prevent the ore collecting at the bottom in too compact a mass.

Steam may also be injected through said coil to assist the reaction but it is necessary in only cold countries. The reaction of the acid generates gas which in bubbles carry the sulphides to the surface, there skimmed or pushed into a hopper. Such thereof as fall

37 back and sink are otherwise recovered. A large proportion of the oil may be recovered from the concentrates in a press. Froment's patents refer to the use of "gas of any kind," that the bubbles will "become covered with an envelope of sulphides" and rising to the surface "form a kind of metallic magma," and that the "formation of these metallic spherules is singularly active if the gas is in a nascent state." Froment's patents, working descriptions and an apparatus therefor, were purchased in 1903 by the patentees of the patent in suit. It may be noted that prior to said purchase, and continuously since, said patentees were and now are associates and metalurgists, chemists, experimenters, inventors and operators in ore reduction in various parts of the world, with headquarters in London. To them and in that behalf have issued patents, domestic and foreign, and they have purchased others. They are of complainants, and much of their work has been for complainants. There is little evidence

of practical use of any of these prior processes, and no substantial evidence that any substantial commercial success has accrued to any of them, or that any of them has had any considerable, continuous, successful operation. Some have operated commercially with some small success, and some are long since abandoned as impracticable, experiments, failures. Froment's process has not been in practical operation. (34)

Complainant's process has, in instances, displaced some of the prior, and has firmly established itself as a new and valuable
38 method of ore reduction. The evidence shows many and large plants thereof built or building in widely separated parts of the world. Its successful operations, practically from discovery, have recovered, and largely from waste and tailings, values aggregating near $9,000,000 and at a profit of near $4,000,000 to the patent owner and its licensees. Detailed comment in respect to anticipation is little necessary save to Froment. Looking to the evidence and therefrom contrasting his process with complainants', Froment's requires several times the quantity of oil that does this in suit, both by examination of the patents and working description and by tests in evidence. Froment crushes the ore in two operations and deslimes it before treatment because the slime is too firm to be treated by his process, while the process in suit needs but one crushing operation and finds slime advantageous and most easily recovered. Froment employs carbonate of lime, the process in suit does not. Froment requires acid and in greater quantity and for a different function, than does the process in suit, which latter may or may not use acid. Both may use heat and both require agitation. Froment agitation only to disseminate the oil. The process in suit for that purpose and also to aerate. Froment's result is by flotation by gas generated in situ, this in suit is by flotation by air introduced by vigorous agitation. Froment's product is like unto a magma, a spongy, pasty mass of oil and metallic particles and more or less of gas bubbles, while this in suit is a froth of oil and metallic particles and air bubbles. Froment's requires oil in such quantity
39 that he deems it worthy of recovery from the concentrates, so far as it can be, this in suit so little oil it disappears, is not sensible to sight or touch upon the concentrates, but only to analysis. In Froment's it would (35) seem that the metallic particles are floated like the basket of balloon, while in this like the very envelope of a balloon. Froment's is costly, while this is cheap relatively. And from the evidence it would seem that Froment's process would fail in practical operation, while this in suit has succeeded. In Froment's, he oils the metallic particles by agitation, then when the mixture is quiescent generates gas therein by quick reaction, followed by immediate and direct rising of the gas bubbles to the surface in which they may come into contact with but few metallic particles. In this in suit vigorous agitation of the mixture beats great and excess volumes of air therein, likely bringing the ultimate air bubbles into repeated contact with many metallic particles. The action of the gas in Froment's is almost explosive in nature. He speaks of proportion of carbonate of lime to be sought

as in his test tube example the reaction may be so sudden and violent as to project the metallic particles out of the tube. Froment's gas bubbles, quick formed and quick rising, it may be, arrive at the surface with expansion still in progress. These or analogous reasons may account for Froment's magma breaking gas bubbles and fragile evanescent froth in so far as his result is like unto froth, and also may account for the process in suit's strong and lasting froth.

One of complainant's experts, Dr. Adolf Liebman, of London, characterizes Froment's product as not a froth but a magma, and his process as one involving the principles of skin flotation assisted by bubbles of carbonic acid. He further testified that in the process in suit is produced a result which was never attained before, that the froth is of a peculiar character, "consisting of air bubbles which, in their covering film, have the minerals embedded in such manner that they form a complete surface all over the air bubbles," that though "the very light and easily destructible air bubbles are carried with a heavy mineral, yet the froth (36) is stable and utterly different, so far as this property is concerned, from any froth known," to him, that "it appears as if the minerals were protecting the tender air bubble like an armor * * * guarding it," that "the froth has a long life," and one is "tempted to say it is permanent, at least as far as metallurgical operations are concerned"; that he himself had "seen a froth standing for twenty-four hours without the least change having taken place"; that a "very striking difference between the previous processes and the process of the patent in suit is the difference between failure and success"; that "the simplicity of the operation as compared with the prior attempts is startling."

Another of complainants' experts, Dr. Charles F. Chandler, of New York, testified that the process in suit is new and surprising; that "there is nothing like it disclosed in the prior art." These and other learned gentlemen gave at length reasons for the foregoing and like views and conclusions. Defendant's expert, Dr. Eugene A. Byrnes, of Washington, is to the contrary.

The differences hereinbefore set out between Froment's process and this in suit are so obvious, numerous, radical and, in many respects, vital, it is clear they constitute different processes. They are different in ingredients, function of some thereof, combination, manipulation, principle and result. Their points of resemblance only serve to accentuate their difference. Broadly speaking, a process is a definite combination of new or old elements, ingredients, operations, ways or means to produce a new, improved or old result. Any substantial change therein, by omission to the same or better result, or by modification or substitution to a better result, or by substitution with different function to the same or better result, is a new and patentable process. New or substantially changed methods whereby the product is bettered, increased, cheapened, may be a new and patentable process.

Thus are the cases: (37)

See Mowry vs. Whitney, 14 Wall. 640.

Dental Co. case, 93 U. S. 494.

Tilghman vs. Proctor, 102 U. S. 722.
Loom Co. case, 105 U. S. 587.
Lawther vs. Hamilton, 124 U. S. 6.
Richards case, 159 U. S. 485.
Steel Co. case, 185 U. S. 420.
Expanded Metal case, 214 U. S. 384.
Rubber Co. case, 220 U. S. 443.

In this suit the doctrine of equivalents has no application. The process in suit is so clearly new that no exhaustive discussion of facts, cases or law is necessary to distinguish it from other
42 processes or to demonstrate its novelty. The patentees herein discovered a new, cheap, simple, practical and useful way or process to combine oil and air and, by agitation, to float and secure the metallic content in ore concentration. The argument that the prior state of the art was such that to anyone skilled therein the process in suit at the time of its discovery was obvious, may, under the circumstances, be well answered by the cases—"knowledge after the event is always easy. * * * But the law has other tests of the invention than subtle conjectures of what might have been and yet was not."

Rubber Co. Case, 220 U. S. 435.
See Expanded Metal Case, 214 U. S. 381.

To whatever extent they drew from the prior art, as they rightfully could, they took the last and successful step. It is urged, however, that as the patent in suit does not specify exact quantities of oil and acid, but a range thereof, it discribes merely an experiment not patentable. It is true, every ore presents its own problem of reduction.

So while all may lend themselves to a general method, (38) each may require some modification of the method. All skilled in the art understand this, and know that in addition to the best scientific theory they must add the light given by trial and practice. Thus, only, in the majority of cases, is good, and the best results obtained in any ore reduction, smelting, milling or concentration. It is believed that at least in cases where the combination or process is not of itself the result sought but only the means thereto, a range
43 of quantities that leaves something to the judgment of the operator is all that can be described and is sufficiently definite.

See Mowry vs. Whitney, 81 U. S. 646.
Wood vs. Underhill, 5 How. 5.

The patent for an ore reduction process that does not is a rarity indeed. To the contention that, as in Froment's process, the agitation must entrain some air like unto that of complainants', and so the latter lacks novelty, it may be observed that if so it was unintentional and unrecognized in that Froment had in mind only flotation by quick acting gas generated in situ, it aided the art none and is unimportant.

See Tilghman vs. Proctor, 102 U. S. 711.

And to the argument that in operating, Froment, in rightful economy and decrease of oil, and in rightful omission of carbonate of lime in treating ore containing it in sufficient quantity, his process would approximate this in suit and arrive at a like froth and hence lack of novelty in the latter, the response is that the fact that infringement may be easy does not impeach an otherwise valid invention, and that if Froment's methods are modified until they approximate complainants' and so produce a like product, the process is no longer Froment's, but is complainants'. At the argument, with apparatus a number of tests, trials and demonstrations were made in the presence of the court, both of the process in suit of Froment's, and of others of the prior art, of much (39) assistance in arriving at conclusions herein.

Upon all the evidence the court is of the opinion the de-
44 fense of lack of novelty and anticipation is not established.

Another defense is that the invention was not joint. It seems the patentees were experimenting with the Cattermole granulation process. An experimenter in their employ, in obedience to their instructions determined on by consultation between all said patentees, and to which each contributed suggestions, gradually reduced the amount of oil until the result was the peculiar froth of the process in suit. He frequently reported to his employers, who frequently observed his labors, and they made a record thereof in the form of reports by two of them to the third, who was chairman of the owning complainant herein, and for whose ultimate benefit the experiments were conducted. This experimenter was but the instrument through which the genius of these patentees found expression. The circumtsances are sufficient to constitute these patentees joint discoverers. At any rate it is not proven they are not. Although some of the claims in issue include elements not absolutely essential, viz: heat and acid, and in respect to which they may afford no protection, they are not invalidated by undeceiving superfluous features, if heat and acid are such. The patent is valid in respect to all claims in issue.

In the matter of the defense of noninfringement, it appears when the charge of infringement was brought to defendant's knowledge, he refused to permit an agent of complainants to inspect his plant.

This agent later secured brief access at night, observed, noted
45 and carried away some of the froth then being produced.

This agent is a mining engineer, and metallurgist. He describes the defendant's plant and gives it as his opinion, being versed in complainants' process, that the process therein was substantially that of complainants. Dr. Chandler analyzed the (40) froth so secured and found its components practically the same as those of froth from samples of some of defendant's materials thereafter furnished and treated by complainants' process, and Dr. Chandler pronounced it as his opinion, based thereon, on the testimony of the agent aforesaid, and on his knowledge of complainants' process, that defendant's operations were of complainants' process. Defendant, pending this suit filed an application for and procured the issue of a domestic patent for a flotation process like to this in suit, which Dr.

Liebman testifies "contains a description of the process disclosed in the patent in suit," and "disclosed an apparatus for carrying on the process in suit." And so doth it seem to the court, although defendant testified he professes ignorance of the amount of oil and acid used in his plant and operations. Enough appears in the evidence to compel the conclusion defendant was using complainants' process and was infringing the claims in issue as charged.

It is worthy of note that during the taking of testimony complainants repeatedly offered to repeat, in the presence of defendant and his counsel, any of the tests or experiments testified to by their experts. They also repeatedly objected to tests, experiments and apparatus and operations of defendant, unless an opportunity
46 was offered complainants to repeat the experiments, and unless defendant furnished like materials therefor, and unless the apparatus was offered in evidence or access to them was given complainants. Save for some of defendant's materials furnished complainant-, it does not appear to what extent, if at all, defendant obviated these objections. Otherwise the consideration of the case might be affected by them.

See Steel Co. Case, 185 U. S. 420.

A decree in accordance herewith, as demanded in the bill of complaint other than for treble damages, will be entered, an accounting to be had before the master.

July 26, 1913.

BOURQUIN, *J.*

Filed July 28, 1913. Geo. W. Sproule, Clerk. (41)

Thereafter the decree of Court was filed herein August 15, 1913, as follows, to wit:

Decree.

At a Stated Term of the United States District Court in and for the District of Montana, held at the courtrooms in the Federal Court Building in the City of Butte, in said District, this — day of ——, 1913.

Present: Hon. Geo. M. Bourquin, District Judge.

47 In Equity.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,

vs.

JAMES M. HYDE, Defendant.

This case having come on for final hearing on pleadings and proofs and having been argued by Henry D. Williams, Esq., in behalf of complainants and Walter A. Scott and Thomas F. Sheridan, Esqs., in behalf of defendants, and due consideration having been had, it is

Ordered, adjudged and decreed that the letters patent of the United States issued to Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot, on November 6, 1906 No. 853,120 for improvements in ore concentration, are good and valid in law, particularly as to claims 1, 2, 3, 5, 6, 7, 9, 10, 11 and 12.

That the said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot were the true, original, first and joint inventors of the invention described in the said letters patent and in the specification annexed thereto and particularly pointed out in claims, 1, 2, 3, 5, 7, 9, 10, 11 and 12. (42)

That The Minerals Separation, Limited, one of the complainants herein, is the lawful, sole and exclusive owner of said letters
48 patent, and that Minerals Separation American Syndicate, Limited, the other complainant, is the exclusive licensee under an agreement whereby both of the complainants must participate in the granting of licenses to use the said invention.

That James M. Hyde, defendant herein, has infringed on said letters patent, particularly as to claims 1, 2, 3, 5, 6, 7, 9, 10, 11 and 12, and upon the exclusive rights of the complainants herein under the same by carrying on the process of ore concentration set forth and claimed in said letters patent as aforesaid.

That a perpetual injunction issue out of and under the seal of this Court directed to the said defendant James M. Hyde, enjoining and restraining him, his confederates, associates, servants, agents, attorneys, clerks and workmen and every person acting for or in his behalf, from any installation or use in any manner of the said patented invention or any part thereof in violation of the rights of the complainants as aforesaid, and from encouraging and inducing others to infringe the said letters patent and from defending other infringers of said letters patent or reimbursing them for the expense of defending against said letters patent, in whole or in part, or otherwise aiding or abetting others to install or use processes of ore concentration in infringement of said letters patent.

That the complainants do recover of the defendant the profits which said defendant has derived, received or made by reason of the aforesaid infringement of said letters patent, and that said
49 complainants do also recover any and all damages they have sustained by reason of such infringement of said letters patent, and it is hereby referred to Clarence N. Davidson, as a master of this court, to take and state the account of such gains, profits and advantages, and to assess such damages and to report thereon with all convenient speed; and the said defendant is hereby directed and required to attend the aforesaid master from (43) time to time as required and to produce before him such books, papers and documents as relate to the matters at issue, and to submit to such oral examination as the master may require.

That the complainants do recover of the defendant other costs and disbursements in this suit to be taxed, and that all further question be reserved until the coming in of the master's report.

August 15, 1913.

GEO. M. BOURQUIN, *Judge.*

Filed and entered August 15, 1913. Geo. W. Sproule, Clerk. (44)

50 And on September 17, 1913, a writ of injunction was issued herein as follows, to wit:

United States District Court, District of Montana.

In Equity.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,
vs.
JAMES M. HYDE, Defendant.

Writ of Injunction.

The President of the United States of America to James M. Hyde, his Confederates, Associates, Servants, Agents, Attorneys, Clerks and Workmen and Every Person Acting for or in His Behalf, Greeting:

Whereas, it has been represented to us in our District Court of the United States for the District of Montana that letters patent of the United States were issued in due form of law on the 6th day of November, 1906, to Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot for Improvements in Ore Concentration, said letters patent being known and distinguished as No. 835,120, and of which Minerals Separation, Limited, is the lawful, sole and exclusive owner, and under which Minerals Separation American Syndicate, Limited, is the exclusive licensee, and that you, the said James M. Hyde, have infringed the exclusive rights secured
51 by the aforesaid letters patent particularly as to claims 1, 2, 3, 5, 6, 7, 8, 9, 10, 11 and 12 thereof by carrying on the process of ore concentration set forth and claimed in said letters patent.

Now, therefore, we do strictly command and perpetually (45) enjoin you, the said James M. Hyde, your confederates, associates, servants, agents, attorneys, clerks and workmen and every person acting for or in your behalf under the penalties which may fall upon you in case of disobedience, that you forthwith and forever desist from further installing or using in any manner the said patented invention, or any part thereof, in violation of the exclusive rights secured by the said letters patent.

Witness the Hon. Edward D. White, Chief Justice of the United States, this 17th day of September, nineteen hundred and thirteen, and in the one hundred and thirty-eighth year of the Independence of the United States of America.

[SEAL.] GEO. W. SPROULE, *Clerk*,
By C. R. GARLOW,
Deputy Clerk.

Return on Service of Writ.

UNITED STATES OF AMERICA,
Northern District of California, ss:

I hereby certify and return that I served the annexed injunction on the therein named James M. Hyde by handing to and leaving a true and correct copy thereof, together with decree attached, with said James M. Hyde, personally, at Berkeley, California, in
52 said District, on the 25th day of October, A. D. 1913.

C. T. ELLIOTT,
U. S. Marshal,
By J. M. FREEMAN,
Office Deputy. (46)

UNITED STATES OF AMERICA,
District of Montana, ss:

I hereby certify and return that I received the within Writ of Injunction on the 20th day of September, 1913, and on the same day I served the same on the Butte and Superior Copper Co. by delivering to and leaving with J. Bruce Kremer, statutory agent and attorney for said defendant company, a true copy thereof, together with a copy of decree of said court, at Butte, Silver Bow County, in said District.

WILLIAM LINDSAY,
U. S. Marshal,
By GEORGE A. McKAY,
Deputy.

Filed and entered Oct. 30, 1913. Geo. W. Sproule, Clerk. (47)

53 And on September 6, 1913, Assignment of Errors was filed as follows, to wit:

District Court of the United States, District of Montana, Northern Division.

In Equity.

No. 1076.

MINERALS SEPARATION, LTD., and MINERALS SEPARATION AMERICAN SYNDICATE, LTD., Complainants,
vs.
JAMES M. HYDE, Defendant.

Assignment of Errors.

Now comes the defendant, by his solicitor, and says that in the interlocutory decree heretofore entered in this cause on the 15th day of August, 1913, the Court erred in the following particulars:

1. The Court erred in finding that patent No. 835,120, in suit, or any of the claims thereof are valid.

2. The Court erred in finding that the defendant has infringed said patent or any of the claims thereof.

3. The Court erred in ordering that an injunction be issued against the defendant restraining him and his representatives from infringing said patent.

4. The Court erred in ordering that complainants shall recover from the defendant profits derived from (48) alleged infringement of said patent in suit.

54 5. The Court erred in ordering that complainants shall recover of the defendant any damages alleged to have been sustained by complainants by reason of alleged infringement of said patent in suit by defendant.

6. The Court erred in referring this cause to a Master to take an account of profits and to assess damages.

7. The Court erred in ordering the defendant and his representatives to appear and testify before said Master.

8. The Court erred in ordering that the complainants do recover of the defendant the costs in this suit.

9. The Court erred in not finding that the patent and the claims thereof in suit are invalid.

10. The Court erred in not finding that the defendant has not infringed said patent or any claims thereof.

11. The Court erred in not dismissing the bill of complaint.

12. The Court erred in rejecting the evidence introduced by defendant regarding certain experiments and tests.

13. The Court erred in rejecting the following testimony of the witness James M. Hyde:

"Q. 45. In your experiments with the Butte & (49) Superior ores have you made any observations of the quantity of oleic acid or other oil used in different experiments, and, if so, with what result?

A. I have experimented in my small test machine, using 500-gram charges of ore with amounts of oil carrying from .6 of

55 1 cc. to 9 cc. getting very satisfactory results with both the smaller and larger amount of oil, the oil referred to being the impure oleic acid or red oil used in the experimental plant at Basin.

A typical test with the use of a very small amount of oil gave results as follows: The pulp treated was a sample of ore from the mill which assayed 23.3 per cent zinc; the concentrates obtained from treating a 500-gram portion of this ore weighed 204.9 grams and contained 52 per cent of zinc; the tailings weighed 283.5 grams and contained 2.2 per cent. of zinc. This test was carried out in the slide test machine, using 2 cc. of a 50 per cent. solution of sulfuric acid and .65 cc. of oleic acid. The actual recovery of zinc in this case amounted to 91.4 per cent. As the specific gravity of the impure oleic acid used is approximately .9, the actual weight of impure oleic acid used was .585 gram. This is equivalent to 2.34 pounds per ton of ore.

In a test in which 500 grams of ore containing 20.3 per cent. of zinc was treated in the small test machine with 9 cc. of oleic acid,

1 cc. of concentrated (50) sulfuric acid and approximately 1700 cc. of water at a temperature of 78° Fahrenheit, 217 grams of concentrates containing 46.5 per cent. of zinc were obtained, and 283 grams of tailings containing .6 of 1 per cent. of zinc. The weight of impure oleic acid used in this case was 8.1 grams, equal to a rate of 32.4 pounds per ton of ore. This is equal to 1.62 per cent. on the weight of the ore or 5.3 per cent. of the weight of the metalliferous mineral contained in the ore. The percentage of recovery
56 of zinc in this test amounted to 99.4 per cent. as figured from the weight of concentrates and their assay value and as 98.4 per cent. when figured by subtracting the total zinc content of the tailings from the total zinc content of the portion of ore treated.

All assays quoted by me in discussing these tests were made by W. R. Hocking, of Butte, Montana.

I have tested the ore similarly with cotton-seed oil, using a sample which I obtained from the Fair Drug Company, of Butte, Montana, and getting phenomenally high recoveries with amounts varying from .27 of a gram to 18 grams per charge of 500 grams of ore or through a range of from 1.08 to 72 pounds per ton of ore.

Using .3 of 1 cc. or .27 grams, of cotton-seed oil in treating a 500 gram charge of ore containing 21.3 per cent of zinc, I obtained concentrates assaying 50.6 per cent of zinc and tailings assaying 1.5 per cent zinc. (51) The percentage of recovery as figured by formula was 86.3 per cent.

Using 5 cc., or 4.5 grams, of cotton-seed oil in treating 500 grams of ore of the same lot, I obtained concentrates containing 45.4 per cent, zinc and tailings containing .8 of 1 per cent. of zinc, the indicated recovery being 96.5 per cent.

Using 10 cc., or 9 grams, of cotton-seed oil in treating 500 grams of ore of the same lot, I obtained concentrates containing 49.5 per cent. zinc and tailings containing .7 of 1 per cent. of zinc, the indicated recovery being 98.1 per cent. The amount of oil used in this case was equal to 5.6 per cent. of the weight of metalliferous mineral present in the parcel of ore.

57 Using 20 cc. or 18 grams of cotton-seed oil in treating 500 grams of ore of the same lot, I obtained concentrates assaying 51.5 per cent. of zinc, tailings assaying 1 per cent. of zinc, and an indicated recovery of 97.2 per cent. The amount of oil used in this test was equal to 11.2 per cent. of the weight of metalliferous minerals in the ore treated.

All of these tests with cotton-seed oil were made upon a sample of ore containing 21.3 per cent of zinc. In each test 1 cc. of pure sulfuric acid was used, and, in all cases, the concentrates were recovered as a froth." (52)

14. The Court erred in rejecting the following testimony of the witness, Eugene A. Byrnes:

"Some simple experiments which I have made in connection with this Froment patent may be of interest as follows:

(1) A glass test tube holding 100 cubic centimeters was half filled with water, corked and well agitated for a brief period. The air in the tube above the water was thus shaken into it, and inti-

mately distributed throughout it in the form of fine bubbles, which, however, quickly rose to the surface of the water and escaped as soon as the agitation was discontinued.

(2) The same experiment was repeated, with the difference that one drop of 'red oil,' the impure oleic acid used by defendant in carrying out his process, was first added to the water. In this case, the fine bubbles of air entangled in the water upon agitation did not quickly float, but remained distributed throughout the
58 water for a considerable period, giving it a milky appearance.

(3) Ten grams of the ore which is being treated by defendant according to his process involved in this suit, finely-powdered, was taken and placed in the empty 100 cc. test tube. This ore, from the "Black Rock" mine of the Butte & Superior Copper Company, assayed about 20 per cent zinc, equivalent to a content of about 30 (53) per cent of zinc sulfid. It also contained rhodochrosite, a manganese carbonate easily decomposed by sulfuric acid to give carbon dioxid gas. Upon adding thirty cubic centimeters of water to the ore in the test tube, some of the mineral floated, by reason of the air within the mass of ore, and the films of air surrounding some of the small particles.

(4) A few drops of sulfuric acid were now added to the ore and water in the test tube, and the mixture was gently heated, whereupon gas was chemically liberated by the action of the acid on the carbonate and sulfid of the ore, evolving carbon dioxid and hydrogen sulfid, and considerable mineral rose to the surface of the liquid, floated by the adherent gas-bubbles, as in the well-known Potter and Delprat methods, heretofore referred to by me. This mineral, however, floated for a brief period only and then again subsided to the bottom of the tube.

(5) One drop of olive oil was now added to the acidulated water and ore in the test tube, and the tube was agitated for a brief space, whereupon a large mass of oiled and aerated mineral floated to the top, in the form of a magma or froth having the character-
59 istics described in the Froment patent. It was found that agitation of the mixture for a brief period, such as was necessary to distribute the drop of oil over the (54) innumerable particles of zinc sulfid in the ten grams of ore and moisten their surface with a film of oil, also aerated the liquid, by the air shaken into it, just as in the experiment numbered (2) above. These fine bubbles of air throughout the mass, as well as the nascent gas chemical-y liberated throughout the same, attached themselves to the oiled particles and assisted in floating them to the top as a froth.

(6) In order to oil the mineral particles without agitation, two drops of cotton-seed oil were dissolved in a few cubic centimeters of ether, and ten grams of the finely powdered 'Black Rock' ore heretofore described was moistened with the solution. The ether was allowed to evaporate, leaving the oil adhering to the mineral particles as a thin film. The oiled ore was then placed in a test tube, thirty grams of water were introduced, five drops of sulfuric acid were added, and the whole was gently heated to cause the sulfuric

acid to react on the carbonate in the ore. The nascent gas generated by the reaction attached itself to the oiled mineral particles and floated them to the top.

(7) Ten grams of the 'Black Rock' ore were mixed, in one instance with one gram of limestone, or calcium carbonate, as prescribed by Froment, and in another instance with a half gram of rhodochrosite, the manganese carbonate occurring in the 'Black Rock' ore, a (55) thin layer or a few drops of olive oil were
60 added, and a few drops of sulfuric acid. On warming to start the reaction, and agitating for a brief period, the oiled mineral floated as a froth."

* * * * * * *

"By using the Hyde slide machine, I have been able to carry out a process of separation corresponding to that of the Kirby patent 809,959. For this purpose, I took 500 grams of the finely-pulverized 'Black Rock' ore which is treated by defendant, and mixed it with from 'three to five times' its weight of water, that is, with sixteen hundred cubic centimeters, acidulated by the addition of 1 cubic centimeter of sulfuric acid, and with an amount of kerosene equal to one-fourth that of the ore, that is, 125 grams. The temperature of the water used was 35° C. On agitating this mixture for thirty seconds by rotation of the central shaft having four radial arms, I was able to so thoroughly oil the sulfid and aerate the oiled particles by the air entrained by the agitation, without any injection of streams of air to float the particles entangled in the tailings, as to produce a floating froth of concentrates nearly half an inch thick. I also roughly imitated the operation of blowing in air carried out by Kirby, by the use of a single tube pushed downward into the tailings at the (56) bottom and moved about therein. By removing this first froth and repeating the operation of aerating by agitating, I was able to remove so much of the zinc sulfid from the ore as to leave the tailings comparatively light in color, that is, consisting largely of gangue.

61 "By the use of this same Hyde slide machine, I have also carried out the process of the Schwartz patents 807,501 and 807,503, thoroughly mixing the ore with the oil before agitating and aerating the mass to produce the froth of concentrates. For this purpose, I took 500 grams of the pulverized 'Black Rock' ore, assaying 20.3 zinc, added 20 cubic centimeters of cotton-seed oil and mixed the whole thoroughly with a blade, giving a homogeneous mass having the consistency of molding sand. The slide apparatus was then filled to the normal level with 1,700 cubic centimeters of water acidulated with one cubic centimeter of sulfuric acid, its temperature being 76° F. The oiled ore was added and the mixture was then agitated for thirty seconds by driving the vertical shaft with radial agitating blades. A heavy froth was produced and removed. The mass was then reagitated for the same period, another froth made and removed, and this operation repeated until six froths had been separated. These froths, combined, were filtered and dried, and their weight was found to be 230 grams. The assayer reported their contents of zinc as 41.7 per cent. The assayer (57)

to whom I refer was W. R. Hocking, manager of "The Rombauer Assay Co.," of Butte, Montana. The tailings from these operations were also removed and dried, and their weight was found to be 277 grams, containing, as reported by the assayer, 0.7 per cent. of zinc. These tailings were nearly white and it was evident to the eye that the metalliferous constituents thereof had been almost entirely removed. In this experiment I did not inject a gaseous fluid,
62 such as air, steam, or carbon dioxid, which Schwarz states may optionally be used, relying simply on the agitation to effect the production of a froth. The specific gravity of cotton-seed oil being about 0.9, the 20 cubic centimeters which I used in this test was about 18 grams, or 3.6 per cent, of the ore treated. The zinc being present in the ore in the form of its sulfid, a content of 20 per cent. of zinc, as reported, corresponds to a content of its sulfid of about 30 per cent. The 500 grams of ore therefore contained about 150 grams of the zinc sulfid, and the 18 grams of cotton-seed oil were thus 12 per cent. of this metalliferous constituent of the ore.

I also carried o t the operation of the Everson patent 348,157, by using the Hy e slide machine to effect the thorough agitation of the oiled ore and removal of the sand by means of acidulated water, floating off the concentrates. This Everson process is similar to that of (58) Schwartz, in that the ore is oiled before it is agitated with acidulated water. For this purpose, I employed the materials and proportions specified in lines 75-92 of the patent, using as an acid the sulfuric acid mentioned in lines 8 and 119. I used eight times the amount specified, that is, sixteen ounces of the pulverized 'Black Rock' ore, and 24 fluid drams of petroleum, in this instance having a gravity of 33° Beaume. I thoroughly mixed the ore and petroleum, producing a homogeneous mass having the consistency of damp sand. I then placed in the slide machine 1,600 cubic centimeters of waters, acidulated with three cubic centimeters of sulfuric acid, having a temperature of 27° C. The agi-
63 tator of the machine was then started and the oiled ore gradually added. The agitation was continued for thirty seconds producing a good froth which was removed. The mixture was then reagitated for thirty seconds and the second froth removed. In order to maintain the acidity of the water, to assist in cutting away the sand from the oiled material, as described by Everson, one cubic centimeter of sulfuric acid was now added. The mixture was then reagitated several times and four froths removed. One cubic centimeter of sulfuric acid was again added and the mixture was successively reagitated three more times and three froths removed. The nine froths were mixed and filtered. The residual (59) concentrates were then washed several times with gasoline to entirely remove the oil therein, and were dried and weighed. Their weight was 144 grams. The tailings were nearly white or quite light-colored, the greater amount of the zinc sulfid having been removed therefrom, as was apparent to the eye.

My tests of the apparatus which I had built in accordance with figure 1 of the Sulman & Kirkpatrick-Picard patent 793,808, shows

that it is capable of producing a very satisfactory froth of concentrates. This apparatus, which I had built to scale from the drawing of the patent, had an agitator of perforated coiled gaspipe three-eighths of an inch in internal diameter, and about four feet long. This coil, when rapidly rotated by power produced a very vigorous agitation and stirring of the liquid in the tank or trough. I tested it without supplying compressed air to the end of the pipe,
64 and found that while it would stir in some air from the surface of the liquid, it was not an efficient means for entangling atmospheric air, as is the Schwartz, Kirby and Hyde agitator with radial arms. When the apparatus was run on an ore pulp consisting of warm water and pulverized 'Black Rock' ore, and compressed air carrying 'red oil' was supplied to the end of the coiled pipe, the air escaping from the perforations of the pipe was thoroughly beaten through the pulp, coating the (60) metalliferous particles with a thin film of oil and attaching bubbles of air to the oiled particles, which were thus raised to the surface by gaseous flotation, producing a thick and satisfactory froth. I skimmed off many handfuls of this thick froth and found it very heavy by reason of its high content of zinc sulfid. It was quite clear that several repetitions of the agitation and defrothing, or continued agitation and removal of the froth, would have separated a very considerable amount of the zinc sulfid from the ore, quite possible rendering the apparatus a commercial one.

I have repeatedly operated the process of the Froment British patent 12,778 of 1902, using the Hyde slide apparatus to effect the brief agitation and frothing and using different kinds of oil and widely differing amounts of oil. The data of some of these Froment operations using the finely pulverized 'Black Rock' ore having a zinc content of 20.3 per cent. are as follows:

(1) A mixture of 492 grams of ore, 1700 cubic centimeters of grams of water, at 70° Fahrenheit, 0.3 cubic centimeters of
65 cotton-seed oil and one cubic centimeter of sulfuric acid was agitated and defrothed five times. The five froths were filtered and dried, giving concentrates having a weight of 170.5 grams reported by the assayer to contain 50.0 per cent of zinc. The tailings (61) weighed 315.5 grams and had a reported zinc content of 4.2.

The process was repeated under precisely the same conditions, except that 20 cubic centimeters of cotton-seed oil or 66 times as much, was used. Six froths were made and removed, and the dried concentrates, plus some oil therein, weighed 211 grams, and had a zinc content of 48.3 per cent. The tailings, plus some oil therein, weighed 292 grams and contained 1.0 per cent of zinc.

The process was repeated under precisely the same conditions, except that 20 cubic centimeters of Ehrmann's California oilve oil was used. Five froths were made and removed, the concentrates, plus some oil, weighing 219 grams and having a zinc content of 44.3 per cent. The tailings, including some oil, weighed 274 grams and contained 0.6 per cent of zinc.

The process was repeated under the same conditions, but using 20 cubic centimeters of 'red oil,' impure oleic acid, from Charles T.

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Perry & Co., of Helena, Montana. Three froths were made, removed and dried. The weight of the concentrates was 65 grams and their reported zinc content was 42.2 per cent. The tailings were not cleaned, but showed on their surface small particles of aggregated mineral, or 'flocks,' perhaps half a millimeter, or one-fiftieth
66 of an inch, average diameter. (62)

The amount of cotton-seed, olive and 'red oil' used in the last three operations was more than 3.6 per cent of the weight of the ore, and more than 12 per cent of the weight of the zinc sulfid in the ore.

The process was repeated under the same conditions using 500 grams of ore, except that ten cubic centimeters of 'red oil' was used. Four froths were made, removed and dried. The concentrates therein weighed 202 grams and had a reported zinc content of 47.5 per cent. The tailings were very white, weighed 288 grams, and contained a reported zinc content of 1.1 per cent. It should be noted that the 'red oil' used in this test was a special or somewhat purer form of oleic acid than that used in the preceding run, more of the solid fatty acids, stearic and palmitic, having been removed by the maker, Charles T. Perry & Co., rendering it thinner and less viscous, pasty or solid at ordinary temperatures.

I have made some tests of the apparatus shown in Figure 1 of the patent in suit, the agitator or mixing vessel and the froth-separating apparatus being made for me to scale as closely as could be determined, the cylindrical vessel containing the agitating cone having a height of 12 inches and a width of 6 inches.

In one run, this vessel was filled with water to the maximum height permissible with rapid rotation of (63) the cone without throwing the water out of the vessel, which was found to be two-thirds of its height, or 8 inches. The amount of water then contained was 3200 cubic centimeters. To this water was added one cubic centimeter
67 of sulfuric acid and three-fourths of a cubic centimeter of 'red oil.' The water was previously heated and had a temperature of 35° C. The cone mixer was now rapidly rotated and 500 grams of pulverized 'Black Rock' ore was introduced, the agitation being continued for ten minutes. The stock-cock in the pipe leading from the vessel to the froth-separator was then opened, and most of the mixture siphoned out. The cone being maintained in motion, wash-water was added to remove the residue, and the vessel was slightly tilted to empty out the portion contained in the concave bottom. Some froth floated down the shallow trough and over the body of the water contained in the spitzkasten passing on into the launder and being collected and filtered. Considerable mineral, in the form of fine individual oiled particles, also floated down on the surface of the water, as a mere film supported by surface tension. This was also delivered to the launder and collected with the froth, care being taken to recover all of the floating mineral whether froth or film. I was not able to verify the statement in line 92 of page 1 of the patent in suit, that the scum or mineral floated derives its power of (64) flotation mainly from the inclusion of air bubbles introduced into the mass by the agitation, by reason of the film flo-

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tation of so much of the mineral distinct from the areated froth. All of the concentrates floated and collected were dried and their total weight was 33 grams. The tailings showed hardly any perceptible change in color from the original ore as was to be expected
68 from the comparatively small amount of mineral removed by flotation.

I then carefully washed out all the apparatus and made another run with 3200 cubic centimeters of water at 35° C. 1.4 cubic centimeters of 'red oil,' 2 cubic centimeters of sulfuric acid and 500 grams of pulverized 'Block Rock' ore. The agitation was here continued for five minutes, all of the mixture in the vessel was washed out with agitation, and all the mineral floating as froths or films was collected and dried. The weight of the concentrates recovered was 49 grams. The tailings were very little changed in color."

Wherefore, the said defendant, James M. Hyde, prays that the said judgment and decree of the said District Court of the United States for the District of Montana be reversed.

SHERIDAN, WILKINSON, SCOTT & RICHMOND,
KREMER, SANDERS AND KREMER,
Solicitors for Defendant.

Service of the foregoing Assignment of Errors and copy thereof received this 13th day of September, 1913.

HENRY D. WILLIAMS AND
O. W. McCONNELL,
Solicitors for Complainants.

Filed Sept. 6, 1913. Geo. W. Sproule, Clerk. By Harry H. Walker, Deputy. (65)

69 In the District Court of the United States in and for the District of Montana.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,
vs.
JAMES M. HYDE, Defendant.

Petition for Appeal and Allowance.

The above-named defendant, James M. Hyde, conceiving himself aggrieved by the decree entered in the above-entitled court on the 15th day of August, 1913, in the above-entitled cause, does hereby appeal from said decree to the United States Circuit Court of Appeals for the Ninth Circuit, for the reasons specified in the assignment of errors, which is filed herewith, and he prays that an appeal be allowed, and that a citation issue, as provided by law, and that a transcript of the records and proceedings, upon which said decree was based, duly authenticated may be sent to the said United States Circuit Court of Appeals, for the Ninth Circuit.

And your petitioner further prays that a proper order, touching the security to be required of him to perfect his appeal be made. (66)

SHERIDAN, WILKINSON, SCOTT AND RICHMOND,
KREMER, SANDERS & KREMER,
Solicitors for Defendant.

70 The foregoing petition is hereby granted and the appeal is hereby allowed this 8 day of September, 1913, and the bond on appeal is hereby fixed at the sum of Five Hundred Dollars ($500.00).

WM. B. GILBERT,
Judge of the United States Circuit Court of Appeals.

Service of the foregoing Petition for Appeal and allowance and copy acknowledged as received this 13th day of September, 1913.

HENRY D. WILLIAMS AND
O. W. [illegible]QNNELL,
Solicitors for Complainants.

Filed Sept. 6, 1913. George W. Sproule, Clerk. By Harry H. Walker, Deputy. (67)

In the District Court of the United States in and for the District of Montana.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,
vs.
JAMES M. HYDE, Defendant.

Bond on Appeal.

Know all men by these presents, That we, James M. Hyde, as principal, and United States Fidelity and Guaranty Company of Baltimore, Maryland, as surety, are held and firmly bound unto the above-named Minerals Separation, Limited, and Minerals
71 Separation American Syndicate, Limited, in the sum of Five Hundred Dollars ($500.00), for the payment of which, well and truly to be made, we bind ourselves jointly and severally, and each of our heirs, executors, administrators, successors and assigns firmly by these presents.

Sealed with our seals and dated this 8th day of September, 1913.

Whereas, the above-named defendant has prosecuted an appeal to the United States Circuit Court of Appeals, for the Ninth Circuit, to reverse a decree rendered and (68) entered in the above-entitled cause in the United States District Court, for the District of Montana, on the 15th day of August, 1913;

Now, therefore, the condition of this obligation is such that if the

above-named defendant, James M. Hyde, shall prosecute his said appeal to effect, and shall answer all damages and costs that may be awarded against him, if he fails to make good his plea, then the above obligation is to be void; otherwise to remain in full force and virtue.

It is expressly agreed by United States Fidelity and Guaranty Company, the surety above named, that in case of a breach of any condition of this bond the Court may, upon notice of not less than ten (10) days to said United States Fidelity and Guaranty Company, proceed summarily in this action to ascertain the amount which said surety is bound to pay on account of such breach, and ren[illegible]r judgment against the said United States Fidelity and
72 Guaranty Company, and award execution therefor.

JAMES M. HYDE,
By ALF. KREMER, *Of Counsel.*
UNITED STATES FIDELITY AND GUARANTY COMPANY OF BALTIMORE, MARYLAND,
[SEAL.] By JOHN C. McCOLLISTER,
Attorney in Fact.

The foregoing bond on appeal is hereby approved this 8th day of September, 1913.

WM. B. GILBERT,
Judge of the Circuit Court of Appeals.

Service of the foregoing bond on appeal acknowledged, and copy thereof received this 13th day of September, 1913.

HENRY D. WILLIAMS AND
O. W. McCONNELL,
Solicitors for Complainants.

Filed September 13, 1913. Geo. W. Sproule, Clerk. By C. R. Parlow, Deputy. (69)

73 In the District Court of the United States in and for the District of Montana.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,
vs.
JAMES M. HYDE, Defendant.

Citation on Appeal.

UNITED STATES OF AMERICA, *ss:*

The President of the United States to Minerals Separation, Limited, and Minerals Separation American Syndicate, Limited, Complainants, and to H. D. Williams, Esq., and O. W. McConnell, Esq., Their Solicitors:

You are hereby cited and admonished to be and appear before the United States Circuit Court of Appeals, for the Ninth Circuit, at the

city of San Francisco, State of California, within thirty (30) days from the date hereof, pursuant to an appeal filed in the office of the Clerk of the District Court of the United States in and for the District of Montana, wherein James M. Hyde is the appellant, and Minerals Separation, Limited, and Minerals Separation American Syndicate, Limited, are the (70) appellees, to show cause, if any there be, why the decree in the said appeal mentioned should not be corrected, and why speedy justice should not be done to the parties in that behalf.

74 Witness the Honorable Wm. B. Gilbert, Senior Judge of the United States Circuit Court of Appeals for the Ninth Circuit, this 8th day of September, 1913, and of the Independence of the United States the One Hundred and Thirty-eighth, at the City of Seattle, in the State of Washington.

WM. B. GILBERT,
Senior Judge of the United States Circuit Court of Appeals for the Ninth Circuit. (71)

Service of the foregoing Citation on Appeal acknowledged and copy thereof received this 13th day of September, 1913.

HENRY D. WILLIAMS AND
O. W. McCONNELL,
Solicitors for Complainants.

[Endorsed:] In the District Court of the United States in and for the District of Montana. Minerals Separation, Limited, and Minerals Separation American Syndicate, Limited, Complainants, vs. James M. Hyde, Defendant. Citation on Appeal. Filed Sept. 13, 1913. Geo. W. Sproule, Clerk. By Harry H. Walker, Deputy.

75 And thereafter, to wit, on Nov. 6, 1913, a condensed statement of evidence was approved and filed, as follows, to wit:

District Court of the United States, District of Montana.

In Equity.

MINERALS SEPARATION, LTD., and MINERALS SEPARATION AMERICAN SYNDICATE, LTD.,
vs.
JAMES M. HYDE.

Condensed Statement of Evidence. (73)

Complainants' Prima Facie Testimony.

Testimony for Complainants of Edward H. Nutter.

NEW YORK, N. Y., Feb. 15-19, 1912.

Direct examination:

I am 36 years of age, a resident of Berkeley, California, and a mining engineer and metallurgist by occupation. I am employed

by Minerals Separation American Syndicate, Limited, one of the complainants, as their chief engineer. Previous to my employment by that company I was employed as an engineer by Minerals Separation, Limited, the other complainant. I am a graduate of Leland Stanford Jr. University in geology and mining, holding the degree of Bachelor of Arts. Since my graduation I have been employed in various capacities in mines and reduction works, usually in a position of responsibility.

76 (Here the witness named several mining companies by which he had been employed as assistant superintendent and superintendent.)

I was employed by Minerals Separation, Limited, in February, 1910; I studied their process in Great Britain, and early in March, 1910, went to Australia and studied the process there; I left Australia in June returning to London, and studied and had a certain amount of supervision of the conduct of tests in the testing works of Minerals Separation, Limited, in London, and about the middle of February, 1911, I came to the United States, where I have since been engaged in testing ores or supervising the tests on ores by the process of Minerals Separation, Limited, and in inspecting mining property in connection therewith.

I have known Mr. James M. Hyde, defendant, about twelve years, and when I first reached London on becoming employed by Minerals Separation, Limited, I found that Mr. (74—1) Hyde had already been employed by Minerals Separation, Limited, and was already in London.

At this time I met Mr. Hyde a number of times in London, and in Wales, where a small concentration plant was being operated by the process of Minerals Separation, Limited. After I returned from Australia I did not see Mr. Hyde again until in December, 1910, when he was again in London and where we met frequently.

77 8 Q. So far as you know, what opportunities were afforded to the defendant, Mr. Hyde, to become familiar with the concentration processes of Minerals Separation, Limited?

A. So far as I know, Mr. Hyde was instructed by the Minerals Separation, Limited's, consulting engineer, Mr. Theodore J. Hoover, as to the nature of the Company's processes, and was afforded every means possible to study these processes in the testing works in London and South Wales, prior to the time that I left for Australia. This instruction consisted of information furnished to Mr. Hyde and myself by Mr. Theodore J. Hoover and of inspection of the testing works in operation in South Wales.

On and after Mr. Hyde's arrival in London in December, 1910, he was afforded every opportunity to inspect and study the Company's testing works in London and did so inspect and study them.

Hyde told me that he had accepted employment by Minerals Separation, Limited, for a year only in order to be free at the end of that period to make a more favorable contract with the company or to use his knowledge of flotation concentration for his own purposes.

I went to Basin, Montana, early in August, 1911, and visited the

mill of the Basin Reduction Works then being (75—2) operated for the treatment of ores by the Butte & Superior Copper Company. I told Mr. Hyde, who was there, that the process operated by him infringed the patents owned by Minerals Separation, Limited, and I asked permission of Hyde to see what he was doing, as we intended bringing suit against him; and Hyde refused my request.

78 Hyde told me that he had laid the patent situation completely and fully before the Butte & Superior Copper Company with reference to flotation concentration and that that company had gone ahead with his eyes open and entered into a contract with him to instal- for that company a flotation concentration plant. Hyde said the process installed was an Everson-Froment process plant with his own modifications. I told him I thought that this was a subterfuge on his part, as we knew what he was doing.

I went to Basin two days later on a south-bound train, which arrived there in the evening, and observed the operations at the Basin plant from the outside by looking through a window and cracks in the wall for an hour or more. I was able to observe some of the general features of the apparatus and then went inside of the building. The shift foreman objected to my presence, but I looked the apparatus over, recognized it as being substantially the same and of about the same size and capacity as the flotation plant in the testing works of Minerals Separation, Limited, in London, and so far as I could see it was operating in the same way.

The shift foreman continued to object to my presence, but I placed my hand in one of the froth separating boxes, noted the feel of the concentrate and liquor, then scooped a sample of the froth concentrate in my hand and went out. As soon as I got outside, I transferred the froth concentrate (76—3) from my hand into a wide-mouthed bottle.

79 I stayed over night in a lodging-house in Basin and next morning went to Helena, whence I sent the sample of concentrate by registered mail to Mr. Henry D. Williams, counsel for complainants.

(Witness identifies the package of concentrates when shown to him while testifying.)

My visit to the Basin plant occurred in the evening of August 10, 1911.

The night foreman of the plant informed me that he was working for Mr. Hyde.

The day after my visit to the Butte plant I made sketch drawings from memory of what I had seen there. (Witness produces these drawings and they are in evidence as Complainants' Exhibit Nutter Drawing of Defendant's Plant, Sheets 1 and 2.)

The numerals 1 to 10 upon my sketches indicate the mixers or agitators. I am not certain that the number is correctly given as I did not count them, but I thought there were about seven mixers in one unit and three in the other. The small letters *a* to *g* indicate the frothing-boxes or spitzkasten attached to and operating in conjunction with the mixers. I am not certain as to the exact number of these, but there were approximately the number shown. B is a

plank connecting the entrance to the flotation plant H with the main mill building; A is a launder which I observed only from the outside; I is a small partly closed court, through which I passed to enter the plant; G is a platform used by workmen in feeding material to the mixers; F is a runway used by the workmen;
80 E is a platform on approximately the same level as the tops of the frothing-boxes; D is a launder which received the flotation concentrate (77—4) from frothing boxes *f* and *g;* C is a launder which received the flotation concentrate from frothing-boxes *a* to *e;* the arrows in all cases indicate the flow of the concentrate in the frothing-boxes and in the launder; J is a space between the end wall and the smaller flotation unit.

In the operation of the plant the pulleys indicated by the Figures 1 to 10 were rotated apparently at the normal speed used in Minerals Separation Company's flotation plants of the same size and capacity, except that number 8 was rotating faster.

The pulp was being brought into the plant by workmen in buckets and wheelbarrows and fed, I think, into mixer No. 1. The concentrate froth from the larger unit was flowing into launder C from the frothing-boxes, though one or two of them were not overflowing at the time of my visit. The concentrate froth from *f* and *g*, the frothing-boxes of the smaller unit, were flowing into launder D and I took the sample of froth from the lip of frothing-box *f*. The froth was the typical appearing agitation froth as made in plants using Minerals Separation flotation froth process.

The normal speed of the agitators or mixers to which I referred is about 400 revolutions per minute. The oily reagent usually used in such plants is oleic acid. The capacity of the Basin plant should be about 40 or 50 tons a day. For the purpose of observing the temperature, I held my hand for possibly a minute in spitzkasten
81 *f* and noted the feel of the solution as to temperature, and as soon as I returned to Butte, the next day, I prepared a bowl of water until it felt to me to be about the same temperature and then ascertained that the temperature in the bowl was 102 and 105 degrees Fahrenheit. Steam was rising from (78-5) the surfaces of the spitzkasten and mixing-boxes in the plant at Basin when I saw it. When I washed my hands after sinking my hand into the liquor at Basin, I noted that they had a sticky or gummy feel, which one usually experiences after wetting one's hands with an acidulated solution.

In my opinion, based upon my knowledge of and experience with Minerals Separation flotation processes, the smaller unit, indicated upon my drawing by the numerals 8, 9 and 10 and the letters *f* and *g*, was a retreatment unit for retreating the concentrate first formed for the purpose of cleaning it and raising the grade of the concentrate, and, in my opinion, the agitation boxes marked 1, 2 and 3 were for the purpose of beating air into the ore pulp, such as is usually done in Minerals Separation process plants, and of agitating the ore pulp for the purpose of forming the concentrate froth, which first appears in the initial spitzkasten *a;* and, in my opinion, the ore pulp, after having the initial froth removed, flows through the

pipe to the mixing-box 4, where it is again agitated and aerated for the purpose of forming a concentrate froth in the second frothing-box *b*, and so on through the mixing-box 5, frothing-box *c*,
82 the mixing-box 6, the frothing-box *d* and the mixing-box 7; and, in my opinion, in the smaller unit, the ore pulp, which I believe to be the concentrate from the first set of frothing-boxes, was fed into the mixer 8 and flowed from thence into the mixer 9, thence into the frothing-box *f* where a froth concentrate was taken off, the remainder of the pulp flowing thence into mixing-box 10, where it was again agitated, and thence into the frothing-box *g*, where a froth was taken off. (79—6)

Cross-examination:

The steps of complainants' flotation process, which is the Agitation Froth process, are not always the same nor always taken in the same order on all ores, but in the application of that process to the Butte & Superior ore the steps would consist of agitating an ore pulp, which had been acidulated with sulphuric acid and to which had been added less than one per cent of an oily reagent; the agitation would take place with considerable vigor, after which the pulp would be conducted into a separating chamber where the sulphide mineral would rise as a froth, which could be flowed off and collected and which would form the valuable concentrate. These steps would be repeated until the required extraction of the valuable constituents from the ore pulp had been obtained.

If it were necessary for me to test an ore for the purpose of determining whether complainants' process was applicable to it, and I found it necessary to make this test without apparatus, I
83 would take the finely ground ore, mix it with water and reagents in a bottle, and shake the bottle vigorously. If the ore was amenable to flotation concentration, some indications of the formation of a froth would be made. If I had a testing machine, of which there are more than one type, I would perform the operation in the machine and would vary the conditions in different tests on an ore to see which set of conditions gave the best results. The variations I would try would consist of agitation with or without sulphuric acid, with different oily reagents, with agitating the pulp before acid should be added, with agitating the water, sulphuric acid and oily (80—7) reagent before adding the ore, with agitating the pulp to some extent with the acidified water before adding the oil, with using water of different temperatures, and, in fact, almost any combination or variation of these conditions that the indications given as I went along seemed to warrant.

The testing plant at London consisted of eight mixers, I think, in what we call the standard plant unit, connected with five spitzkasten, I think the number is, entirely similar in appearance and apparent operation to the larger apparatus unit in the plant at Basin, Montana, together with means for feeding the pulverized ore, which at London was fed dry to the first and second mixers, and tanks for catching and collecting the products of any test. In these mixers

were agitators, and the ore, water, sulphuric acid, if used and
84 oily reagent, were fed into the first or second mixer or perhaps later in some tests, and the ore pulp was vigorously agitated and then flowed into the initial spitzkasten, where a flotation froth was removed. From near the bottom of this spitzkasten a pipe led to the next mixer, where the ore pulp was again agitated and flowed into the second spitzkasten; and so on. If it was necessary to use heated solutions in testing any particular ore, the solutions were heated by adding steam to the pulp in one or more of the mixers.

When in Australia I saw the operations of two of the large plants at Broken Hill, New South Wales, wherein the Minerals Separation process was employed on a practical scale. These plants were working on material, in one case coming directly from an ordinary wet concentration mill, and, in the other case, the material was zinc-bearing tailings which resulted from former operations of ordinary wet concentration mills. In the first plant the material (81—8) coming from the wet concentration mill was dewatered and then fed to the flotation plant, where it was mixed with sulphuric acid and whatever frothing reagent happened to be in use at the time. The ore pulp was heated by adding steam, agitated in mixers similar to the ones already described, only larger, flowed into spitzkasten where flotation froths were removed, and so on until the operation was finished. The solution circuit was a closed one. The operation in the other plant was similar as to the flotation part, except that dry material was fed in regrinding pans, where the coarser par-
85 ticles were reground to the requisite fineness and the whole pulp was then passed through a classifier which in part dewatered it, and the thickened pulp went to the flotation apparatus. The agitators were rotated at a speed of about 200 to 225 revolutions per minute.

It is believed that the froth is produced in Minerals Separation's process by beating the ore pulp with sufficient violence to aerate the solution, and that the resulting bubbles became attached to the mineral particles and when these have a chance to rise to a quiet surface they do so, forming the concentrate froth. This explanation seems reasonable, but from the nature of the phenomena it is a theoretical explanation and open to the doubt which theoretical explanations usually are open to.

At the time of my visit to the Minerals Separation testing plant at Wales, the ore was being tested under one set of conditions, but I understood that it had been tested under other conditions previously and it is rather difficult to say whether such tests were successful as all results obtained are indicative and important. (82—9)

In the Cattermole process it was usual to provide an upcast of water which washes the gangue mineral of the ore up and away from the granules which have been formed, the granules being heavy enough to sink through the upcast, and I understand that the chief difference in the results brought about by Minerals Separation
86 flotation process and the Cattermole process is due to the difference in the quantity of oil used.

If in attempting to carry out Minerals Separation's flotation pro-

cess I found that some of the metalliferous mineral agglomerated and sank to the bottom, I would alter the adjustment of operations step by step until I found a condition wherein sunken granules were not discharged with the tailings. I would try the following adjustments in my attempt to find proper conditions to produce flotation: (1) I would alter the rate of flow of pulp through the plant; (2) I would alter the speed of agitation; (3) I would alter the quantity, or (4) the kind of oil used on the particular ore being treated; (5) I would alter the dilution of the solution circuit with reference to salts dissolved therein; (6) I would alter the temperature of the solution circuit; and (7) I would vary the internal arrangement of baffles or other diverting devices so as to affect the direction of flow of the ore pulp. All of these adjustments might have some effect or any of them might have an effect upon the formation of the agglomerations that I have described. It is likely that an inspection of a plant by one skilled, like myself, in the art would indicate to me the probable adjustment called for. I cannot say whether, if the oil supply needed readjustment, I would increase or diminish the supply when the process was operating imperfectly. The effects are so various with different (83—10) oils under different conditions that it is hard to say in advance what I would do without studying
87 a particular case of ore treatment where sinking agglomerations were being formed.

I could in particular cases lay down a definite rule as to the course to be pursued to produce the flotation effect without that effect being accompanied by the settling of agglomerated masses of sulphide. If an ore were being treated and it was found that the readjustments previously mentioned by me did not diminish the agglomerating and sinking effect, and if the quantity of oleic acid used was in excess of the usual amount found necessary, I would lay down a rule that the quantity of oleic acid should be diminished. When oleic acid is used, better results are obtained in a heated circuit than in a cold circuit. I have never experimented with solid oleic acid and do not know whether it would be impossible to produce flotation with solid oleic acid or not. It would be an advantage to liquefy oleic acid by heat in order to regulate the amount being added, but whether or not solidified oleic acid would be an advantage or a disadvantage I do not know. I would expect that when an oil was used that was viscid at the temperature of the ore pulp and good results were not being obtained, better results would be obtained if the temperature of the pulp were raised.

The use of the minimum quantity of oil which can be used without unfavorably affecting the recovery is important from the standpoint of economy.

I have not had sufficient information about the Cattermole
88 process to enable me to state in figures the exact point where Cattermole's precipitation results in (84—11) contradistinction to the frothing of Minerals Separation frothing process, and I presume that, with different ores, some experimentation would be necessary to determine the point in question.

149 X Q. Referring to the operations which you saw at Basin, Montana, you stated that the froth flowing into the launders was the

typical appearing agitation froth as made in plants using the Minerals Separation flotation froth process. What are the characteristics of this typical froth?

A. It would be a bit hard to describe these characteristics in such a way that another could recognize the froth as being typical, but I have come to know this froth when I see it as I know my wife when I see her, though I doubt if I could describe her with sufficient accuracy so that she would be recognized if seen on the street by the person to whom I described her.

150 X Q. Perhaps you can describe some of the characteristic features of this froth, even if you cannot enable the Court to recognize it when it sees it. Will you attempt to do so?

A. It is usually a froth similar in some ways to a sudsy froth and would be not unlike, I think, such a sudsy froth if it were imagined full of finely divided mineral matter. It floats on the surface of water, its color depends on the color of the mineral contained in it and forming a part of it, the bubbles are of various sizes and
89 there is frequently what might be called a pitted condition to the upper or air surface of the froth due to the breaking of some of the bubbles. When oleic acid is being used as the frothing agent, there is what might be called a toughness or persistency to the froth that can usually be noticed. (85—12)

The Elmore vacuum process is a process in which oil and acid are agitated with the ore pulp and the air is exhausted from the vessel containing the pulp, the reduction in pressure causing air which was previously in solution in the water of the pulp to change to bubbles of free air, and the sulphuric acid reacting with limestone in the ore to produce carbonic acid gas. I have heard, and it is my understanding, that the carbonic acid gas and air both perform the same function in the Elmore vacuum process, one supplementing the other and each contributing to the same result.

168 X Q. Assuming that in a series of operations gases produced in different ways are introduced under precisely similar conditions into a pulp containing ore to which insufficient oil has been added to produce flotation by the effect of the oil itself, is it your judgment as an expert in this art that these gases introduced into the pulp under similar conditions would have any different effect or function growing out of the fact that they had been produced or generated in different ways?

A. As flotation concentration is an experimental art, I am unable to give an intelligent judgment on this point, as I have not
90 witnessed any experiments which would enlighten me in the matter.

Putting aside the question of profit of the operation, I believe from the tests which I have made that salable concentrates could be produced by the Minerals Separation flotation process from ores of the Butte & Superior mine containing as little as one per cent of zinc in the form of zinc sulphide. Selected samples of zinc ore may consist of practically pure zinc sulphide, but an ore carrying twenty per cent of metallic zinc is a good grade ore for (86—13) treatment by such process under the normal working conditions in established mining camps.

When I was employed by Minerals Separation, Limited, certain literature was placed at my disposal by Mr. Hoover of that Company for my information, and among this literature was the record of the testimony in the patent suit between Minerals Separation, Limited, and the Elmore Company, a large mass of experimental data on studies of the phenomena called surface tension, a résumé of patents relating to flotation and a file of flotation patents and other papers that I do not remember at this time. I read the material so given to me.

In the Elmore vacuum process, by the time the pulp reaches the vacuum chamber the most of the air has been drawn out of solution and there is not as much air left in solution as there is ordinarily in water at the same temperature under atmospheric pressure. The mixing blades rotate at a much less speed than we have found necessary in operating the agitation-froth process.

91 In the agitation-froth process there must be agitation of considerable vigor such as would be represented by the agitation produced by blades of 12 or 14 inches diameter rotating at a speed in the neighborhood of 400 revolutions per minute. In the small testing machines, a speed in the neighborhood of 1,000 revolutions per minute or more is necessary. The entraining of air, that is, the drawing of air below the surface of the liquid, begins as soon as the speed of agitation is sufficient to give a broken surface to the water and I think the breaking up of the oil would begin almost immediately after the agitation become- sufficient to break the water surface, assuming that the oil was (87—14) floating on the water surface before agitation began.

So far as my observations have gone, the introduction of air had practically no effect upon the mode of separation desired in the Cattermole process.

With some ores good results are obtainable at atmospheric temperatures in the application of Minerals Separation flotation process, but I would lay down a general rule that heat should be used in testing ores such as those in the Butte & Superior mine.

My judgment, based on small scale experiments of the Butte & Superior ore, is that a recovery of ninety-five per cent or better of the zinc values, in a concentrate assaying fifty-one per cent or more of zinc, would be entirely reasonable to expect by the application of

92 Minerals Separation agitation froth process, but in operations on a commercial scale of this process by Minerals Separation, Limited, concentrates have never been obtained in the case of zinc ores running as high as fifty-one per cent zinc. In this practice the material treated was in many ways different from the Butte & Superior Company's ore.

In treating ores by the process practiced by Minerals Separation, Limited, the practice is sometimes modified or affected by the presence of carbonates in the ore treated. This depends on the ore being treated. The presence of carbonates in ore usually makes for a higher consumption of acid than would be the case if they were not there. In an ore, therefore, in which carbonates occur, if it should be found necessary to use acid, such an adjustment of conditions and appa-

ratus would be advisable as would minimize the expense incident to any chemical reaction between the acid and the carbonate in the ore. It might (88—15) easily be found possible to remove the carbonate from the ore to a considerable degree prior to the application of the flotation process, which would have the effect of reducing the acid consumption, and also it would probably be found advisable to operate the flotation froth process at as low a temperature as gave good results. The whole matter is one of balancing costs and of using such a modification of the process as yields the best net result from a standpoint of profit.

93 The presence of carbonates in an ore in the treatment of which it is found necessary to use acid for the effect which that acid has on the formation of a froth, if in that ore there is a carbonate which reacts with the acid, increases the amount of sulphuric acid necessary; and the effect of the acid upon the formation of a froth might not become evident until the chemical reaction with the carbonate had been more or less completed. In such case it would be necessary to use the amount of acid required to satisfy the chemical reaction with the carbonate in the ore and the amount of acid required to produce the froth, thus necessitating a larger amount of acid than would be necessary in the treatment of an ore containing no carbonate or other acid-consuming mineral. One of the products of the reaction between sulphuric acid and a carbonate is carbon dioxide gas and it would be liberated in the ore pulp, but I would not necessarily consider that the carbon dioxide gas so liberated in the pulp contributed to the flotation of the oil-coated sulphide particles; in fact, such a froth would not form until the reaction with the carbonate had ceased. I would not think that the flotative effect, secured after the addition of the excess of sulphuric acid over and above that necessary to satisfy the carbonate, (89—16) was probably caused in part by the carbon dioxide evolved from the carbonate.

94 In the bottle test which I have previously described with an ore wherein the carbonate was present in insufficient quantity to react with all the acid chemically, but was still there in quantity sufficient to produce some carbon dioxide, it would be reasonable to believe that the carbon dioxide had contributed in some measure to the formation of the froth, assuming that a froth had been formed, but the same thing would not necessarily be true in the case of carbon dioxide gas evolved in the pulp during the commercial application of the process. I can easily conceive that there would be a difference in the effect of the carbon dioxide in these two cases on account of the difference in treatment which is given in a commercial plant as compared with the treatment in a bottle, as the carbonic acid gas formed might escape from the pulp before the pulp had reached the part of the apparatus where the froth was formed.

In the bottle test, the shaking of the bottle produces a rather violent agitation of the pulp mixture, which brings about the introduction of air into the pulp in such a way as to result in a froth being formed.

As to what finally becomes of the air which is entrained in the

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pulp during the agitation which forms part of the Minerals Separation flotation process, presumably some of it goes to form the froth and some of it escapes without forming a froth, and it seems reasonable that some of the air goes into solution in the water of the pulp and that some of the air so dissolved is subsequently liberated.

In the operations of Minerals Separation flotation (90—17) process in Australia, which I have witnessed, from 15 to 25 pounds of sulphuric acid were used per long ton of ore.

We have found a fairly definite relationship to exist be-
95 tween the results obtained with the small scale or test machines as compared with the results obtained with a commercial apparatus operating under like conditions of temperature and approximately the same proportions of the different ingredients. The results are not identical.

There are two types of small test machines which we have used in the testing of ores by the flotation froth process (the witness then describes the Slide-Machine, later introduced as an exhibit, and an apparatus of the type of the Gabbett or Cone Mixer later also introduced as an exhibit, but in the apparatus witness describes modified by the substitution of a rotating impeller for the rotating cone). There were a number of different types of small testing machines in the London testing works that had been used at different times, but I never observed them carefully. The tests which I witnessed in Australia were made with a test machine of the cone mixer type modified as above described.

It has been my observation that air can be bubbled into or through an ore pulp without giving any flotative effect. With the agitation froth process, however, it would be reasonable to expect that, if the pulp was conducted in a thin layer to a trough or over an apron between the mixing or agitating-box and the box in which the froth was permitted to form, the bubbles coming to the surface of the pulp would come to the surface as a flotation froth and not escape into the air.

96 The ore supplied to the flotation plant at Basin upon the occasion of my visit was a wet ore pulp or mud and not a free flowing pulp. I did not see acid or oil added to the pulp. (91—18)

Testimony for Complainants of Charles F. Chandler.

NEW YORK, N. Y., Feb. 20-27, 1912.

Direct examination:

I am 75 years of age, a resident of New York, and a chemist by occupation. I was educated at Harvard University and the Universities of Goettingen and Berlin. I studied physics, chemistry, mineralogy and geology, and began to teach these subjects at Union College in 1857, lecturing among other things upon the chemistry of the metals and teaching qualitative analysis, assaying, mineralogy and geology. In 1864 I came to New York and was one of the

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founders of the school of Mines of Columbia University, teaching particularly chemistry, including the chemistry of the metals, for a time geology, and for a considerable length of time assaying. I had the good fortune to be the inventor of the assay weights which are now generally employed in the United States and Great Britain. I have had to do with minerals and ores and the extraction of metals from their ores. I have frequently been called upon during the last forty years to investigate matters connected with the metals and their extraction and in patent and other litigations involving ores and
97 metals, such as the ores of gold, silver, lead, copper, tin and antimony. I was employed as an expert in the litigations involving aluminum, the casting of steel, the hardening of armor plates, and the manufacturing of carborundum. I was an expert in the famous Johannesburg suit of Thomas and McArthur relating to the cyanide treatment of gold ores, and was an expert in the cyanide filtration suit of Butters and Moore, and in other cases. I have received the degree of Doctor of Philosophy from the University of Goettingen, Doctor of Laws from both Union (92—19) College and Columbia University, Doctor of Medicine from the University of New York, and Doctor of Science from Oxford.

I have examined the patent in suit No. 835,120, issued November 6, 1906, and I understand it. This patent is entitled "Ore Concentration," and I cannot indicate the character of the invention better than by quoting:

"This invention relates to improvements in the concentration of ores, the object being to separate metalliferous matter, graphite and the like from gangue by means of oils, fatty acids, or other substances which have a preferential affinity for metalliferous matter over gangue."

Before beginning to describe the nature of their invention, the patentees refer to the Cattermole granulation process, in which oily matters were employed in ore concentration in a manner totally different from that of the patent in suit. I cannot do better than quote from the specification, as follows:

"In the process described in the previous United States
98 patent, No. 777,273, granted to A. E. Cattermole, an amount of oil varying from four per cent to six per cent of the weight of metalliferous matter present is agitated with an ore pulp, so as to form granules which can be separated from the gangue. In the previous United States Patent, No. 777,274, granted to A. E. Cattermole and others, a similar method of separation is employed, oleic acid being produced in situ in the ore pulp."

In both these patents so large an amount of oily matter is employed as to agglomerate together the metalliferous metal into granules or pellets, which, owing to the specific gravity of the metalliferous metal remain at the bottom of the vessel even when an up current is used, while the nonmetalliferous matter or gangue, which being considerably heavier than water, *are* nevertheless carried up through the liquid and discharged, the result being a comparatively complete separation of the metalliferous matter remaining (93—20)

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below from the nonmetalliferous matter which passes away with the upward current of water.

The patentees then go on to explain the nature of their invention. They make the following statements:

"We have found that if the proportion of oily substance be considerably reduced—say to a fraction of one per cent on the ore—granulation ceases to take place, and after vigorous agitation there is a tendency for a part of the oil-coated metalliferous matter to rise to the surface of the pulp in the form of a froth or scum."

This discovery is the foundation of the invention described and claimed in this patent. The patentees then go on to describe the peculiarities of the process which they have devised, making the following statement:

"This tendency is dependent on a number of factors."

The first item refers to the use of a small quantity of acid and is given in the following words:

"Thus the water in which the oiling is effected is preferably slightly acidified by adding, say, a fraction of one per cent. up to one per cent. of sulphuric acid or other mineral acid or acid salt, the effect of this acidity being to prevent gangue from being coated with oily substance, or, in other words, to render the selective action of the oil more marked; but it is to be understood that the object of using acid in the pulp according to this invention is not to bring about the generation of gas for the purpose of flotation thereby, and the proportion of acid used is insufficient to cause chemical action on the metalliferous minerals present."

The second factor referred to as influencing the tendency for the oil-coated metalliferous matter to rise to the surface of the pulp and form a froth or scum is the application of heat to the pulp, that is, the mixture of ore and water, and is stated in the following quotation:

"Again, we have discovered that the tendency for the oily substance to disseminate through the pulp and the rapidity with which the metalliferous matter becomes coated is increased if the pulp is warm."

In other words, warming quickens the action of the oil. (94—21)

The third factor which the patentees mention refers to the necessity of reducing the ore to a state of fine subdivision so that the oiled particles of metalliferous matter may readily rise to the surface in the form of foam. It is stated in the following words:

"The formation of froth is assisted by the fine pulverization of the ore, and we find that slime mineral most readily generates scum and rises to the surface while larger particles have less tendency to be included in the froth."

The next topic taken up by the patentees in the specification refers to the fact that ores are not all alike and that different ores may require the use of different oily materials in order to secure the desired separation of the metalliferous matter from the gangue by the production of a froth. The following is a statement from the specification:

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"The proportion of mineral which floats in the form of froth varies considerably with different ores and with different oily substances, and before utilizing the facts above mentioned in the concentration of any particular ore a simple preliminary test is
101 necessary to determine which oily substance yields the proportion of froth or scum desired."

This is the general statement of the invention. The patentees then follow the statement with an example, selecting an ore containing ferruginous blende, that is, sulphide of zinc containing iron, and galena, which is sulphide of lead, and a gangue consisting of quartz, rhodonite, and garnet. They direct that this ore finely powdered is to be mixed with water containing either a fraction of one per cent or even one per cent of a mineral acid or acid salt, mentioning sulphuric acid or waters containing ferric sulphate.

The oily matter which they recommend in this case is oleic acid in very small proportions from 0.02 per cent to 0.5 per cent on the weight of the ore; reducing these (95—22) quantities to pounds of oleic acid per ton of 2,000 pounds of ore, I find that 0.02 per cent of oleic acid is four-tenths of one pound or less than six and one-half ounces to the ton, while 0.5 per cent is ten pounds to the ton of ore of oleic acid.

They direct that the mixture be warmed to from 30° to 40° Centigrade, which would be 86° to 104° Fahrenheit, and they further direct that the mixture shall be briskly agitated for from two and a half to ten minutes, until the oleic acid has been brought into efficient contact with all the mineral particles in the pulp.

They then state that

102 "When agitation is stopped, a large proportion of the mineral present rises to the surface in the form of a froth or scum, which has derived its power of flotation mainly from the inclusion of air bubbles introduced into the mass by agitation, such bubbles or air films adhering only to the mineral particles which are coated with oleic acid."

They then state—

"The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1 per cent of the ore; but this proportion has been found suitable and economical."

0.1 per cent of the ore is two pounds of oleic acid to the ton of 2,000 pounds of ore, that being the ton usually employed in the United States.

The patentees state that if the ore is crushed to ninety meshes to the linear inch, which means so that it will all pass through a sieve of that mesh, that the froth may contain as much as 70 or 80 per cent of the metalliferous matter present in the ore. All that remains after the froth is produced is to remove the same by skimming or otherwise.

No particular apparatus is claimed in this patent for the carrying out of the process, although, in order to make (96—23) the process clearer to the reader, an apparatus is figured and described which is suitable for the purpose.

This is the process of the patent.

Turning to the claims I notice that—

Claim 1 calls for—

103 "1. The herein-described process of concentrating ores which consist in

(*a*) mixing the powdered ore with water,

(*b*) adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter (amounting to a fraction of one per cent on the ore),

(*c*) agitating the mixture until the oil-coated mineral matter forms into a froth, and

(*d*) separating the froth from the remainder by flotation."

Claim 2 calls for—

"2. The herein-described process of concentrating ores which consists in

(*a*) mixing the powdered ore with slightly acidified water,

(*b*) adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter (amounting to a fraction of one per cent on the ore),

(*c*) agitating the mixture until the oil-coated mineral matter forms into a froth, and

(*d*) separating the froth from the remainder by flotation."

Claim 3 calls for—

"3. The herein-described process of concentrating ores which consists in

(*a*) mixing the powdered ore with slightly acidified water,

(*b*) adding a small proportion of an oily liquid having
104 a preferential affinity for metalliferous matter (amounting to a fraction of one per cent on the ore),

(*c*) warming the mixture,

(*d*) agitating the mixture until the oil-coated mineral matter forms into a froth, and

(*e*) separating the froth from the remainder by flotation." (97—24)

Claim 5 calls for—

"5. The herein-described process of concentrating ores which consists in

(*a*) mixing the powdered ore with water,

(*b*) adding a small proportion of oleic acid amounting to 0.02-0.5 per cent on the ore,

(*c*) agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith and

(*d*) separating the froth from the remainder by flotation."

Claim 6 calls for—

"6. The herein-described process of concentrating ores which consists in

(*a*) mixing the powdered ore with water containing a fraction of one per cent of sulphuric acid,

(*b*) adding a small proportion of oleic acid amounting to 0.02-0.5 per cent on the ore,

(*c*) agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, and

(*d*) separating the froth from the remainder by flotation."

105 Claim 7 calls for—

"7. The herein-described process of concentrating ores which consists in

(*a*) mixing the powdered ore with water containing a fraction of one per cent of sulphuric acid,

(*b*) adding a small proportion of oleic acid amounting to 0.02-0.5 per cent on the ore,

(*c*) warming the mixture to 30°–40° Centigrade.

(*d*) agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, and

(*e*) separating the froth from the remanider by flotation."

Claim 9 calls for—

"9. The process of concentrating powdered ores which consists in separating the mineral from the gangue by (98—25)

(*a*) coating the mineral with oil in water containing a small quantity of oil,

(*b*) agitating the mixture to form a froth, and

(*c*) separating the froth."

Claim 10 calls for—

"10. The process of centrating powdered ores which consists in separating the mineral from the gangue by

(*a*) coating the mineral with oil in water containing a small quantity of oil,

(*b*) warming the mixture,

106 (*c*) agitating the mixture to form a froth, and

(*d*) separating the froth."

Claim 11 calls for—

"11. The process of concentrating powdered ores which consists in separating the mineral from the gangue by

(*a*) coating the mineral with oil in water containing a small quantity of oil, and a quantity of acid insufficient to cause chemical action on the metalliferous minerals present,

(*b*) agitating the mixture to form a froth, and

(*c*) separating the froth."

Claim 12 calls for—

"12. The process of concentrating powdered ore which consists in separating the minerals from gangue by

(*a*) coating the minerals with oil in water containing a fraction of one per cent of oil on the ore,

(*b*) agitating the mixture to cause the oil-coated mineral to form a froth, and

(*c*) separating the froth from the remainder of the mixture."

In reviewing these claims I notice that in all of them, first, the ore is to be mixed with water.

Second, the mixture is to be agitated.

Third, an oily liquid is to be added.

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Further, in three of the claims, 5, 6, and 7, the particular (99—26) oily liquid, oleic acid, is directed.

107 And further, I notice that in all of these claims, the amount of oily liquid is specified, either as a fraction of one per cent, as in claims 1, 2, 3 and 12, or as a small quantity in claims 9, 10 and 11, or to the percentage, in the case of oleic acid, .02 to .50 per cent in claims 5, 6 and 7.

Fourth. The addition of acid to the water is mentioned in claims 2, 3, 6, 7 and 11, and sulphuric acid is referred to specifically in claims 6 and 7. The percentage of acid to the water is specified as a fraction of one per cent in claims 6 and 7. In claim 11 the percentage of acid employed must be insufficient to cause chemical action on the metalliferous minerals present.

Fifth. The application of heat or the warming of water or mixture of oil and water is mentioned in claims 3, 7 and 10, and in claim 7 it is said, "warming the mixture to 30°—40° Centigrade," equivalent to 86°—104° Fahrenheit.

Sixth. In every claim the separation of the froth is mentioned as the end of the process.

(Dr. Chandler identified the concentrate taken from the Basin plant by Mr. Nutter.) The sample contained in the bottle is not in the same condition that it was when I received it, at which time it was moist and adhered more or less to the inside of the bottle. I washed it out with pure ether, using several applications, filtering the ether and returning the small portion of the material which came out with the ether to the bottle and allowing the little

108 ether which adhered to it to evaporate. Consequently the powder is now dry.

After extracting with ether, I evaporated the etherial (100—27) solution in a glass vessel, finding that it left behind an oily residue. The oily residue responded to tests for oleic acid and I concluded that it was oleic acid. I detected the presence of a small quantity of sulphuric acid.

I found the oleic acid to weigh .0737 gram; that the dry concentrate weighed 20.452 grams, the percentage of oleic acid to concentrate being 0.36%, which was equivalent to 7.2 lbs. per ton of 2,000 lbs. of concentrate.

I had an analysis made of the concentrate with the following results:

	Percentages.
Insoluble residue	3.04
Zinc	55.47
Sulphur of Zinc	27.14
Zinc sulphide	82.61
Iron	1.80
Lead	0.59
Copper	0.76
Manganese	2.99

I did not determine the amount of sulphur in the ore, but simply calculated the amount necessary to convert the zinc into sul-

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phide. I did not determine the earthy matter in the ore. The water associated with the ore in the bottle weighed 8.55 grams. The bottle now contains all of the material except that employed in making the analysis. I examined the powder contained in the
109 bottle critically under the microscope and found that it was a metallic mineral having the appearance of zinc blende, or sulphide of zinc. I also subjected it to a sieving test and found that 99.91 per cent passed through a 150 mesh sieve, while 9/100 of one per cent. failed to do so. I would say that, in speaking of the sieve, the number represents the number of holes per linear inch, 150 mesh representing 150 holes to the inch.

(The bottle of dry concentrate produced by the witness was offered in evidence and marked "Complainants' Exhibit, Defendant's Concntrate.") (101—28)

It is stipulated by the parties to the suit that a specimen of defendant's ore in partially crushed condition was received by complainants and that the specimen produced marked "Complainants' Exhibit, Defendant's Coarse Crushed Ore" is the specimen so received and subjected to a subsequent crushing operation.

I have made an analysis of "Complainants' Exhibit, Defendant's Coarse Crushed Ore" with the following result:—

	Percentages.
Insoluble Material	57.37
Zinc	21.18
Copper	0.48
Oxide of iron	3.55

I have had "Complainants' Exhibit Defendant's Coarse Crushed Ore" ground so that it all went through a 40-mesh sieve; the material which had passed through the 40-mesh sieve was then
110 sifted on an 80-mesh sieve and the portion which failed to pass through the latter sieve was ground again until it did all pass through. The material so ground was that in the bag introduced as "Complainants' Exhibit, Defendant's Coarse Crushed Ore."

I made the tests with this ore in the slide machine described by Mr. Nutter in his testimony. I took 400 grams of the ore with 1600 grams of water warmed to 40° Centigrade; to the mixture of ore and water, 100 cubic centimeters of 5% sulphuric acid was added. I then added 0.7 of one cubic centimeter of oleic acid from a bottle brought over from London by Mr. Ballantyne; the oleic acid added being equivalent to 0.64 gram. The mixture was agitated at 1800 revolutions a minute and the froth taken off; the water taken off with the froth was then replaced with fresh warm water, the mixture again agitated and the second froth taken off. This was repeated until six successive froths (102—29) had been taken off, the last one in very small quantity. Further effort produced no more froth. The six froths that had been so formed were filtered, returned to the slide machine, warm water added, 10 cubic centimeters of 5% sulphuric acid added, and the mixture agitated a little; another 10 cubic centimeters of 5% acid added and the

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mixture again agitated. The mass was then allowed to stand a few minutes and the froth removed and filtered, constituting the concentrate. The material which did not rise to the surface
111 as froth was collected and preserved under the name of middlings. The procedure above described I call "Experiment No. 1."

I conducted a second experiment, which I call Experiment No. 2, with the same quantity of ore, water and oleic acid as in Experiment No. 1. The oil used was the regular oleic acid from my supply at Columbia University, made by Charles Cooper & Co. The amount of acid used in Experiment No. 2 was not exactly the same as in No. 1, 30 cubic centimeters being first added, 10 cubic centimeters after the second froth had been removed, 10 cubic centimeters after the third froth, and 10 cubic centimeters after the fourth froth. The treatment of the froth was the same as in Experiment No. 1, except that only 10 cubic centimeters of dilute sulphuric acid were employed.

Experiment No. 3 was conducted in the same manner as Experiments Nos. 1 and 2, the oleic acid being that made by Charles Cooper & Co. and 30 cubic centimeters of sulphuric acid being employed in the beginning and 10 cubic centimeters being added after the third foam had been removed and 10 cubic centimeters after the fifth foam had been removed.

The fourth experiment was conducted precisely in the (103—30) same manner as the third with the same materials.

It is stipulated that a specimen of defendant's feed to his flotation plant was received by counsel for complainants on or about
112 February 10, 1912, and that the specimen produced and marked "Complainant's Exhibit, Defendant's Feed to Flotation Plant" is such specimen.

The experiments just described by me were made before the receipt of the specimen "Complainants' Exhibit, Defendant's Feed to Flotation Plant."

It was stipulated that a specimen of defendant's candlemaker's red oil or impure oleic acid was received by complainants' counsel with the specimen last referred to, and that the specimen produced and marked "Complainants' Exhibit, Defendant's Oleic Acid" is such specimen.

I conducted experiments with "Complainants' Exhibit, Defendant's Feed to Flotation Plant" and "Complainants' Exhibit, Defendant's Oleic Acid" in the slide machine already referred to, using first 400 grams of ore and 1300 grams of water, 30 cubic centimeters of 5% sulphuric acid, and 0.8 cubic centimeters of defendant's oil. I used 0.8 cubic centimeters of the oil because it was hot. I had to place defendant's oleic acid in hot water in order to melt the stearic and palmitic acids which had separated in solid form in the bottom of the bottle. By melting them I was able to make the oil uniform by shaking.

The separation of solid fatty acids from the liquid oleic acid must have been caused by the very unusually cold weather which prevailed at the time it was on its way to New York. The quantity of

oil which I measured out hot was substantially identical with the 0.7 cubic centimeters which I had measured cold in my pre-
113 vious experiments. (104—31) The amount of sulphuric acid used in this experiment with defendant's feed to flotation plant and defendant's oleic acid was 30 cubic centimeters at the beginning and none afterwards, it being the same 5% solution used in the previous experiments. The treatment of the froth was carried out precisely as in experiments Nos. 1 to 4 and I refer to this experiment as No. 5.

I performed as sixth experiment identical with my fifth experiment, except that I used the oleic acid manufactured by Charles Cooper & Co.

I produce the following table showing the results of the first four experiments in the weights of ore and oleic acid used, the weights of the tailings, middlings and concentrates obtained, and the amount and percentage of oleic acid on each and the percentage of the oleic acid on each to the whole amount of oleic acid found.

	Exp. 1.	Exp. 2.	Exp. 3.	Exp. 4.	Average four experiments
Ore taken	400g.	400g.	400g.	400g.	.....
Oleic acid used	0.64g.	0.64g.	0.64g.	0.64g.	.....
Tailings	226g.	184g.	200g.	199g.	202.25
Oleic acid on tailings	0.1715g.	0.084g.	0.092g.	0.103g.	0.112
% oleic acid to tailings	0.075%	0.046%	0.046%	0.052%	0.05
% oleic acid to whole oleic acid	20.8%	8.9%	10.7%	13.9%	13.6%
Middlings	87g.	127g.	69g.	39g.	80.5
Oleic acid on middlings	0.3885g.	0.350g.	0.281g.	0.101g.	.28
% oleic acid to middlings	0.45%	0.28%	0.40%	0.26%	0.35
% oleic acid to whole oleic acid	47.2%	37.1%	32.8%	13.6%	32.7%
Concentrates	77g.	79g.	121g.	152g.	107.25
Oleic acid on concentrates	0.2635g.	0.508g.	0.486g.	0.537g.	.44
% oleic acid to concs	0.34%	0.64%	0.40%	0.35%	0.43
% oleic acid to whole oleic acid	33.0%	53.9%	56.5%	72.4%	53.7%
Middlings and concentrates	164g.	206g.	190g.	191g.	187.75
Oleic acid on them	0.652g.	0.858g.	0.767g.	0.638g.	.72
Oleic acid percentage	0.40%	0.41%	0.40%	0.34%	0.39
% of oleic acid to whole oleic acid	79.2%	91.0%	89.3%	86.1%	86.4

•(105—32)

114 I now produce a table showing the results of the fifth and sixth experiments in the same manner, the following being the table:

	Exp. 5.	Exp. 6.	Average of all six experiments.
Ore taken	400g.	400g.	.....
Oleic acid used	0.64g.	0.64g.	.....
Tailings	220g.	223g.	207.
Oleic acid on tailings	0.079g.	0.067g.	0.0994
% oleic acid to tailings	0.036%	0.030%	0.047%
% oleic acid to whole oleic acid	11.3%	10.9%	12.7%
Middlings	106g.	130g.	93.
Oleic acid on middlings	0.3445g.	0.395g.	0.31
% oleic acid to middlings	0.32%	0.30%	0.33%
% oleic acid to whole oleic acid	49.4%	64.1%	40.7%
Concentrates	68g.	42g.	89.8
Oleic acid on concentrates	0.2735g.	0.154g.	0.37
% oleic acid to concentrates	0.40%	0.37%	0.42%
% oleic acid to whole oleic acid	39.2%	25.0%	46.5%
Middlings and concentrates	174g.	172g.	182.8
Oleic acid on them	0.618g.	0.549g.	0.68%
Oleic acid percentage	0.35%	0.32%	0.37%
Percentage of oleic acid to whole oleic	88.7%	89.1%	87.2%

The averages of the first four experiments appear in the last column of the table of those experiments, and the averages of the entire six experiments appear in the last column of the table of Experiments 5 and 6.

I noted that when I added together the oleic acid extracted from the tailings, the middlings and the concentrates, I found the sum total to exceed somewhat the amount of oleic acid which I had used in my experiment. This suggested that there must have been fatty material in the ore itself, and upon examination I found that the ore averaged for each 400 grams thereof, .172 grams of fat,
115 and that the ore employed in my last two experiments averaged .434 grams of fat for each 400 grams thereof. This solid fat was presumably solid fat from candle ends. (106—33)

I had had the percentage of zinc in the ores employed in my experiments determined by analysis and prepared tables showing the results of my experiments in the percentages of recovery. The work involved so many zinc determinations that I did not make a determination of zinc on the results of the first experiment. The tables give the quantity, percentage of zinc, and grams of zinc and the quantity of ore experimented upon. The first three tables represent experiments 2, 3 and 4 made with defendant's coarse crushed ore after it had been ground. Experiments 5 and 6 were made with defendant's feed to flotation plant. The tables exhibit the weights of the middlings, tailings and concentrates and also the percentage of the same. They also exhibit the percentage and the grams of zinc in each and the percentage of the zinc contained in the ore which was recovered in each.

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	Weight.	% Wt.	Zinc, %	Zinc, Gms.	Zinc, % recovered.
Exp. 2:					
Ore	400	100.	22.36	89.44	....
Tailings	184	46.	1.48	2.22	2.5
Middlings	127	31.75	34.57	43.91	49.1
Concts.	79	19.75	51.95	41.05	45.9
Concs. & Middlings	206	51.50	41.23	84.96	95.
Total	390	97.50	.....	87.18	97.5
Loss	10	2.50	.....	2.26	2.5
Exp. 3:					
Tailings	200	50.	0.88	1.76	2.
Middlings	69	17.25	33.41	23.06	25.8
Concs.	121	30.25	51.61	62.45	69.8
Concs. & Middlings	190	47.50	45.00	85.51	95.6
Total	390	97.50	.....	87.27	97.6
Loss	10	2.54	.....	2.17	2.4
Exp. 4:					
Tailings	199	49.75	1.24	2.47	2.7
Middlings	39	9.75	18.81	7.33	8.2
Concs.	152	38.	51.73	78.63	87.9
Concs. & Middlings	191	47.75	50.24	85.96	96.1
Total	390	97.50	.....	88.43	98.8
Loss	10	2.50	.....	1.01	1.2
(107—34)					
Exp. 5:					
Ore	400	100.	22.42	89.68	....
Tailings	220	55.	1.44	3.17	3.5
Middlings	106	26.5	44.35	47.	52.4
Concs.	68	17.	56.05	38.12	42.5
Concs. & Middlings	174	43.5	48.89	85.12	94.9
Total	394	98.5	.....	88.29	98.4
Loss	6	1.5	.....	1.39	1.6
Exp. 6:					
Tailings	223	55.75	1.38	3.08	3.4
Middlings	130	32.50	46.45	60.38	67.3
Concs.	42	10.50	57.39	24.10	26.9
Concs. & Middlings	172	43.	49.10	48.48	49.2
Total	395	98.75	.....	87.56	97.6
Loss	5	1.25	.....	2.12	2.4

In order to arrive at the suitable quantity of oleic acid to the ore, I took into consideration the amount of oleic acid which I found in the sample of concentrate received from complainants' counsel through Mr. Nutter. That amounted to 0.36%. I then assumed that that concentrate represented one-third of the original ore. This amount would be 133 grams of concentrate from the 400
117 grams of ore which I intended to use. To this quantity I added one-third as much more for an assumed loss on the tailings. This gave 0.64 grams of oleic acid for the 400 grams of ore which I intended to employ. This amounts to 0.16% of oleic acid on the ore; that is, 16/100 of one per cent, which is well within the quantity specified in the claims of the patent, which quantity is from .02 to .5 per cent or from 2/100 to ½ of one per cent. This percentage .16 represents 3.2 pounds of oleic acid per ton of ore and

my experiments have proved this a very popular quantity to secure the results described in the patent in suit.

16 Q. Basing your answer upon the experiments which you have conducted with defendant's ore and with defendant's (108—35) oleic acid and upon the description given by Mr. Edward H. Nutter in his testimony of the ore concentration process as carried on by the defendant at Basin, Montana, please state whether or not, in your opinion, the invention pointed out in claims 1, 2, 3, 5, 6, 7, 9, 10, 11 and 12 of the patent in suit was employed by the defendant.

A. In my opinion it was. I base this opinion upon the character of the concentrates which Mr. Nutter forwarded to New York upon his statement of what he saw at the works, and upon my experiments, in which I carried out the process described and claimed in the patent. The results of my experiments satisfy me that the process described and claimed in the patent and in the claims
118 which you mention would produce just such a concentrate as Mr. Nutter forwarded, and that the apparatus and process which he states that he saw at the works of the defendant would carry out that process and were carrying it out at the time he observed it.

(Notice was then given by counsel for the complainants that the charge of infringement will be limited to claims 1, 2, 3, 5, 6, 7, 9, 10, 11 and 12 of the patent in suit.)

Cross-examination:

I do not know anything about whether the process of the patent in suit would be applicable to the separation of graphite from earthy matter with which it occurs in nature.

The word "oil" is applied to a great variey of products. There are three classes of substances which are properly called oils. First the fatty oils and to this class belong all those oils which are capable of being (109—37) converted into soaps by treatment with caustic alkali and the class includes the fatty acids when they are liquids at ordinary turpentine. The second class includes the so-called essential oils, mostly of vegetable origin, of which oil of turpentine and oil of eucalyptus are the best examples. The third class includes the petroleum products, such as kerosene oil, lubricating oils, etc. Ordinary beef fat or lard or mutton fat yield a fatty acid which is a mixture of stearic acid, palmitic acid and oleic acid, which can be separated by straining into solid stearic acid and commercial oleic acid or red oil.

119 I consider the word "oily" as used in the patent in suit as equivalent to the word greasy in common language. All the fatty oils are greasy. The fatty acids are greasy, of which oleic acid is one; petroleum products are greasy, and the essential oils are greasy. The words "oily" and "greasy" are substantial equivalents in ordinary language, and it seems to me that it is to this greasy property of the oil that the success of the process of the patent in suit is due.

I have no reason to doubt that, as stated in the patent in suit,

line 27, page 1, oleic acid produced in situ might be used instead of oleic acid directly added to the pulp.

The expression "metalliferous matter," occurring in line 20, page 1, of the patent in suit, is used for the purpose of distinguishing the common metals from the mineral matter associated with them which is nonmetallic in character, such as quartz, clay, feldspar, carbonate of lime and such minerals. In the case of the feed to flotation plant with which I experimented, the term metalliferous (110—37) matter as used in the patent in suit would apply to the zinc sulphide or blende. The expression "metalliferous mineral matter," appearing in Cattermole patent 777,273, lines 74 and 75 of page 2 thereof, is synonymous with the expression "metalliferous matter" used in the patent in suit in line 20, page 1 thereof.

The word "say," in lines 29 and elsewhere in similar connection in the patent in suit, is equivalent to the expression "for
120 example." In almost all chemical processes the proportions of reagents may be varied to a certain extent without interfering with the process, sometimes a little more and sometimes a little less of a reagent being desirable, according to the varying nature of the materials operated upon. The person practicing an invention such as that of the patent in suit might vary slightly from the quantities set forth in the patent if he found it advisable in order to secure the best results as described in the patent with the material being tested.

27 X Q. Is it your understanding that, in the treatment of any selected material, such as that in evidence as Feed to Flotation Plant, there is some definite point in the quantity of oil used at which a transition takes place between the effects described in the Cattermole patents referred to in the patent in suit and the effect of flotation for which the process of the patent in suit is described as being useful?

A. I am sure I don't know any exact point of demarcation. Cattermole describes a process in which he used five or six per cent of oil and so manipulate- his material as to cause the metalliferous constituents of the ore to form heavy granules which settle to the bottom, while the nonmetalliferous material or gangue is floated off the (111—38) top or carried off by the current. In the patent in suit, by the use of a fraction of one per cent of oil and brisk agitation in water, the metalliferous constituent of the ore is floated off at the top as a froth, while the nonmetalliferous mineral, the
121 gangue, settles to the bottom. Not only is there an absolute and radical difference in the amount of oil employed, but there is also a radical difference in the mode in which the oil is applied to the ore. There is no object in the Cattermole process of agitating his material so as to produce froth and send his metalliferous mineral to the surface. That is just what he does not want to do. On the other hand, in the patent in suit there is no object in so manipulating materials as to cause the metalliferous material to remain at the bottom. That is just what the patentees do not want to do. So that if either the patentees of the patent in suit or Cattermole so varied their processes that either would produce the results

described by the other, he would cease to be carrying out his own process.

I have no knowledge of the Cattermole effect and the effect of the patent in suit taking place simultaneously, that is, at the same time and in a single operation. I have no opinion upon the subject as I do not know.

30 X Q. I invite your attention to the passage extending from line 31 to line 35, page 1, of the patent in suit, in which it is stated that part of the oil-coated metalliferous matter rises to the surface, and ask what becomes of the remainder of the oil-coated metalliferous matter?

A. It remains in the tailings. I have found in all my experiments that I failed to bring to the surface all of the metalliferous mineral; particles of it were left distributed in the gangue,
122 but they were never in the form of granules. They were always as isolated particles, having (112—39) for some reason failed to be carried to the surface.

31 X Q. Did you ever see any of these bodies which the Cattermole patents refer to as granules?

A. I have. They consist of particles of metalliferous mineral glued together by oil; not containing a sufficient quantity of oil to make them lighter than water, they necessarily remain at the bottom.

32 X Q. How large a proportion of the ore from which these granules were formed was agglomerated into these granules which you saw?

A. Why the greater part of the metalliferous mineral contained in the ore. The gangue was carried away by the up-current, leaving the metalliferous minerals in the form of granules.

In the operations described in the patent in suit, the presence of a mineral acid facilitates the formation of the froth. Exactly how it does this I do not know, but I have noted in my experiments that I could hasten and increase sometimes the formation of froth by adding a little more acid and I sometimes tested the liquid with methyl orange to see if it had an acid reaction. If it did not, I added a little more acid.

Whether the presence of carbonates in the material being treated by the procedure described in the patent in suit would affect the quantity of mineral acid necessary or desirable, would depend upon the nature of the carbonates and upon the nature of the mineral acid. Some acids are much more active than others when
123 they are in a very dilute condition, and some carbonates are not affected by dilute acids, particularly by sulphuric acid. We never use sulphuric acid in our analytical processes by itself for dissolving minerals, because it is not as active as some other acids. (113—40)

39 X Q. In treating an ore containing eight per cent of zinc in the form of blende and the remainder of the ore consisting of non-metalliferous gangue, what would be the maximum and the minimum amounts of oil per ton of ore to be used according to the direc-

tions appearing in lines 72-79, page 2, of Cattermole patent No. 777,273?

A. 9½ lbs. is the minimum and 14½ lbs. is the maximum.

40 X Q. Will you please state what percentage of the amount of ore figured as a whole these quantities of oil named in your last answer represent?

A. Reckoned in percentages, the minimum is 0.48% and the maximum is 0.71%.

41 X Q. In treating a similar ore containing four per cent of zinc in the form of blende and the remainder of the ore consisting of nonmetalliferous gangue, what would be the maximum and minimum amounts of oil per ton of ore to be used, according to the directions appearing in lines 72-79, page 2, of the Cattermole patent No. 777,273? In answering this question, please also state what percentages of the ore as a whole the amounts you give constitute.

A. Naturally the amount of oil used with a four per cent ore would be half the amount for an eight per cent ore. The amount,
124 therefore, would be a minimum of 0.24%, a maximum of 0.36%, or a minimum of 4¾ lbs. to the ton, and a maximum of 7⅛ lbs. to the ton.

42 X Q. In treating an ore containing eight per cent of zinc as blende, and the remainder consisting of nonmetalliferous gangue, what would be the maximum and the minimum amounts of oil per ton of ore to be used according to the instructions appearing in lines 28-30, page 1, of (114—41) patent No. 835,120, this being the patent in suit? Will you also apply the same question to an ore containing four per cent of zinc in the form of blende?

A. The patent in suit, as I understand it, does not specify any particular quantity of oil with regard to the percentage of zinc present in the ore. The specification simply gives general indications of possible quantities that might be found useful. In lines 28-30, to which you refer in your question, no specific quantity is mentioned. The inventors simply state, referring to the Cattermole patent which has just been previously discussed, that four to six per cent of the weight of metalliferous matter present is employed, that they have found that if the proportion of oily substance be considerably reduced, say to a fraction of one per cent on the ore, granulation ceases to take place. What this fraction of one per cent is, they do not mention. The only way in which I can interpret this fraction of one per cent is by referring to other portions
125 of the specification, where this fraction of one per cent is expressed in figures; for example, at line 81, of page 1, of the specification, is the following statement; speaking of the ore:

"To this is added a very small proportion of oleic acid (say from 0.02 per cent to 0.5 per cent on the weight of the ore.)"

That is, from 1/50 of one per cent up to one-half of one per cent. The specification does not intimate that these proportions of oil of oleic acid are to be used indiscriminately on the ores. Special directions are given for preliminary tests with different ores and different

oils. Consequently it does not follow from the specification that the maximum quantity of oleic acid mentioned would be used on four per cent or eight per cent ores. On the (115—42) contrary, it is especially stated, beginning at line 96 on page 1 of the specification,

"The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1% of the ore, but this proportion has been found suitable and economical."

43 X Q. We will refer again to lines 28-30, page 1, of the specification of the patent in suit, and in connection therewith I would like you to state whether 9/10 of one per cent is not "a fraction of one per cent"?

A. It certainly is, but the paragraph does not indicate that that is the fraction that the inventors refer to. We have to seek further information in the specification to ascertain what particular
126 fraction they are referring to by the expression "a fraction of one per cent."

44 X Q. In treating an ore containing eight per cent of zinc as blende and the remainder consisting of nonmetalliferous gangue, or, for that matter, containing any other amount of zinc as blende, what amount of oil in pounds per ton would result from computing the same as .9 of one per cent on the ore?

A. .9 of one per cent on 2,000 pounds would be 18 pounds.

45 X Q. Taking the proportion of oil as .5 of one per cent, please compute the amount of oil to be used upon the ore referred to in the last preceding question.

A. It would be 10 pounds per ton.

46 X Q. You have stated in discussing lines 28-30, page 1, of the patent in suit that it is necessary to seek further information in the specification of that patent to ascertain what particular fraction of one per cent of oil is referred to. Will you kindly point out in this patent any passage definitely setting forth any particular fraction (116—43) of one per cent that is applicable to the treatment of ores generally?

A. I will examine the specification in its entirety and see what I can find. The first reference to any proportion of oily substance is found in the lines which you have referred to on page 1, lines 28-30. That paragraph, however, is not a statement of any particular quantity which the patentees recommend. It is simply a statement of a discovery which the patentees have made. The first definite statement which I find as to quantity of oily matter
127 is given on page 1, line 81, after the patentees have stated the desirability of simple preliminary tests. At line 81, the patentees say:

"To this is added a very small proportion of oleic acid (say, from 0.02 per cent to 0.5 per cent on the weight of the ore)."

These extremes represent from .4 of a pound per ton of ore to 10 pounds per ton of ore. The patentees do not state on what particular condition of the ore this variation of quantity depends, whether it depends upon the percentage of zinc in the ore or some

other quantity, but they do indicate that the selection of quantity between these extremes must rest with the person familiar with the art who practices the process and it is fair to assume that such person would decide how much oleic acid to use by the results of the simple preliminary tests suggested by the patentees.

The next place in the specification where I find a reference to the proportion of oleic acid or oily matter is at line 99 on page 1, where I find the following statement:

"The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1 per cent of the ore; but this proportion has been found suitable and economical." (117-44)

0.1 per cent of the ore is two pounds to the ton.

And further I notice that in all of the claims in suit the amount of oily liquid is specified either as a fraction of one per cent, as in claims 1, 2, 3 and 12, or as a small quantity in claims 9,
128 10 and 11, or in a percentage in the case of oleic acid .02 to .50 per cent in claims 5, 6 and 7.

47 X Q. Please state how you would proceed in conducting a preliminary test as referred to in the passage extending from line 61 to line 69, page 1, of patent 835,120 in suit.

A. In the same way that I conducted my experiments which I have described in my previous testimony. I should take a weighed quantity of finely pulverized ore and a suitable quantity of water to make a fluid to mix it up; I should put them into a suitable vessel provided with an agitator; I should add a weighed quantity of acid and put in a small quantity of oily matter, noting, of course, the exact proportion of each material. In making my first experiment, assuming, of course, that I am a person skilled in the art, I should use about the proportions that I had previously found to give satisfactory results with other similar ores. If my first selection of proportions of water, acid and oil gave satisfactory results, I should know that I had put in enough of each. I might then, for the purposes of economy, reduce the proportions of oil or water until I found the minimum quantity that would give satisfactory results with this particular ore.

If, on the other hand, I did not obtain satisfactory results with the quantities of oily matter and acid which I employed, I should think one or the other of these substances had been used either in deficient or excessive (118—45) quantities, and I should use
129 my experience or judgment in changing the proportions for one or more further tests.

48 X Q. The teaching of the patent, as I understand you, consists in directions to perform experiments with different amounts of oil and acid until that amount is hit upon which produces a froth, and then adopting that amount, and that the determination of what is intended to be included within this patent is defined by a result as distinguished from any definition of means to secure such result. Is this correct?

A. As I understand it, the object of this invention as described

in the specifiation and claims is to extract as completely as practicable the valuable metallic minerals from the ore.

This result is to be accomplished in a certain way, which is described and claimed in the patent, that is, by agitating the ore in extremely fine powder in water which is slightly acidulated and to which a minute quantity of oily matter is added, these additions and the character of the agitation being such as to cause the metalliferous particles to come to the surface as a froth, while the worthless gangue minerals remain at the bottom of the vessel. Now it is self-evident that no two ores are exactly alike, either in the nature of their metallic minerals or in the percentage, and it is equally self-evident that, that being the case, no hard-and-fast rule can be laid down for all cases as to the quantities of acid or oily matter to be employed. All that the inventors can say in their specification and claims is the statement as to about how much, in general,
130 acid and oil they have found to accomplish the desired results on ores containing metalliferous minerals.

I don't think your question correctly expresses the (119—46) teaching of the patent. It is not merely necessary to "produce a froth." One might produce a froth and not get out half the valuable material in the ore. Anyone skilled in the art would understand that he must conduct his preliminary tests until he has ascertained the amount of oil and acid which this particular ore requires for its successful working by the process of this patent. This process does not merely consist in adding oil and acid to the water containing the pulverized ore, but it consists in agitating, agitating it briskly, as the specification says, and agitating it so as to produce a froth which shall contain the valuable metallic minerals of the ore.

49 X Q. In following out the directions of the patent in suit, do you find anything in that patent to define the amount of oil to be used other than the results secured by using different amounts of oil, such results taking into account not only the production of a froth but the amount of valuable mineral carried by the froth, as you have suggested?

A. I find on page 1 of the patent, beginning at line 96, the following statement; which I have already quoted:

"The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under
131 0.1 per cent of the ore; but this proportion has been found suitable and economical."

This paragraph certainly contains a direction defining the amount of oil which the patentees find to be suitable and economical. In another place they have intimated that the quantity is not necessarily fixed for all ores and that the person skilled in the art practising the process should make preliminary tests or, at least, may make them, with his particular ore, to discover, if possible, a more suitable proportion than 0.1 per cent or under. I am trying to (120—47) see what else your question calls for in the way of an answer. You ask me "do you find anything in that patent to define the amount of oil to be used other than the results secured by using different amounts of oil"? I think the last three words in my quota-

tion from the patent cover everything that is possible, where, in speaking of the proportions to be used, he uses the words "suitable and economical." Necessarily the proportion suitable is the proportion that will cause the largest possible percentage of the valuable metallic minerals to rise in the form of froth, while the largest possible percentage of worthless gangue remains at the bottom of the vessel.

And "economical" naturally refers to costs, which would mean the oil or its equivalent and the proportion thereof which accomplished the desired result at the least expense. I don't mean to say that I find in the specification that it is anywhere stated that one must select the oily matter and determine the proportion
132 thereof which will be most efficient and least expensive. Anyone skilled in the art would read them into any patent. The object of every patented process is to accomplish a result for commercial purposes and such considerations are always understood.

50 X Q. Following your argument, then, the proportion of oil suitable is the proportion indicated by the results, is it not?

A. The best proportion, certainly. That, however, might vary in different localities, according to cost of materials.

51 X Q. By the expression "best proportion" I take it that you mean the proportion of oil which will make the process a success?

A. Yes, a commercial success. The oil that might be (121—48) most successful as to minimum quantity might be too expensive for practical use. So, in considering the economical phase of the question, the cost of the oil necessary to accomplish the result has to be taken into consideration. That is indicated by the use in the specification, at line 101, page 1, of the words "suitable and economical."

52 X Q. In treating the ore mentioned in the passage beginning at line 72, page 1, of the patent in suit, said ore consisting of ferruginous blende, galena and gangue consisting of quartz, rhodonite and garnet, and assuming that oleic acid costs 5½ cents per pound, "black oil" 17½ cts. per gallon, red oil (Standard Oil Company's lubricant) 23 cts. per gallon, and Standard Oil Company's
133 paraffin oil 22 cts. per gallon, said prices being in effect at the plant, which of these oils would you use and how much of each in carrying out the process of the patent in suit?

A. I should use the one that would give the best results at the least cost. Of course, I can't decide which one it would be sitting here in a lawyer's office. I should have to go into the laboratory and try them in a preliminary test, and, as the patentees say, they have found 0.1 per cent of the ore to be a suitable quantity in case of oleic acid, I should probably begin with that proportion of each of the oils which you have mentioned. Of course, I should not be able to avoid thinking that the oil which cost the least per gallon would be most inviting for trial, but on making my preliminary test I might find that the process could be carried out successfully by using so much less of the most expensive oily material, which is the oleic acid, that that would be the most economical. The choice, therefore, of oily material and the quantity which I should use would have to be determined (122—49) by my preliminary tests. You have stated

in your question the price of oleic acid per pound and the prices of the other materials per gallon. I think 5½ cts. per pound would be about 41 cts. a gallon for the oleic acid.

53 X Q. Assuming that, from your viewpoint, oleic acid proves to be the cheapest and most efficient, what amount of it would you use in treating the ore previously referred to and described in the patent beginning at line 72, page 1, of the patent in suit?

134 A. I should use the smallest quantity that would accomplish the result sought. I should probably begin with 0.1 of one per cent, because the inventors have stated that they have found that quantity to be suitable and economical, but, as they say the quantity required may be under that amount, I should naturally reduce the quantity until, for my particular ore, I found the minimum quantity that would accomplish the result of the process of the patent, suitably and economically. I have not mentioned all the considerations that would come in. It is not necessary for the success of the process that every particle of metallic mineral should be taken out of the ore. It often increases the expense of a process enormously to extract the last percentage of valuable mineral which it contains, and it is, therefore, often very much cheaper to arrange a process of extraction so that one, or even several, per cent of valuable metallic mineral may be left behind in the gangue.

That is one of the considerations that is covered by the expression "economical."

From the very nature of the case, it would be impossible to give in the specification of the patent in suit exact figures or to limit the process to exact figures as to oil, acid, etc., because no two ores are alike in their (123—50) composition and consequently no two ores would behave exactly alike and the proportion of materials would be varied with the variations in composition of the ore; even the ore from the same mines would not be uniform and any person operating a process at a mine would be obliged, in order to obtain

135 economical results, to vary the proportion of materials. The patentees, it seems to me, have been as explicit as the nature of the case permits in mentioning proportions. They have even selected, in their example, an actual ore, that of Broken Hill, New South Wales, and they have stated the proportions of acid and oleic acid which they found by experience to be suitable for this ore.

Variations in the ore interfere with the possibility of prescribing exact proportions of oil and acid for the treatment, and as great precision as is possible from the nature of the case is to be found stated in the example given in the patent in suit.

It is easy to determine the rate of flow of pulp and it is easy to regulate the rate of flow of oil by simple mechanical devices. If the oil is contained in a suitable receptacle and has leading from it a discharge pipe provided with an adjustable cock, this cock will be so adjusted as to deliver any desired quantity of oil within a given time to match the flow of the pulp.

75 X Q. Assuming that the constantly flowing pulp contains quantities of ore which vary from time to time, ore which necessarily varies in composition as you state, and assuming that it is

necessary to maintain some relation between the quantity of oil and the quantity of ore, such relation varying with the composition of the ore, can you describe any means whereby oily matter could be added to the constantly flowing stream of pulp in the amounts necessary (124—51) to fulfill the conditions stated?

A. The patentees have stated in their specification that,
136 in working that ore which they described, they found one-tenth of one per cent of the weight of the ore to be suitable and economical. Now assuming that this ore varies from time to time in composition, that quantity was evidently sufficient with this ore, notwithstanding the variations. When the ore had one composition, it may have been more than was necessary. It would be pretty difficult and hardly pay for the trouble to vary the quantity of oil for such moderate variations in the composition of the ore as would be likely to occur within short intervals with a finely pulverized ore which had been through the stamps or crushers and the mills, and any intelligent person skilled in the art, in charge of the operations at a mine, could hardly fail to make preliminary tests from time to time on his ore, as suggested in the patent, to see what, if any, variations he should make in the proportion of oil employed.

76 X Q. I think you have failed to answer the preceding question, which inquires whether you can describe any means whereby oily matter could be added to the constantly flowing stream of pulp in the amounts necessary to fulfill the conditions stated, said conditions being the maintaining of some specified relation between the quantity of oil and ore, said relation varying with the composition of the ore, and the quantity of ore carried by the water also varying from time to time.

A. If I were running such a plant, I should test the tailings from time to time and, if I found they contained more than a
137 minimum amount of valuable metallic mineral, I should increase the quantity of oil or the quantity of acid or both, by opening the stop-cock a little wider in the (125—52) supply pipe so as to discharge a little more oil and a little more acid in a given time. That would be the easiest way to adjust proportions, or I might discharge continuously the maximum quantity of oil and acid which I had found necessary to accomplish satisfactory results and, when less than the average was required, permit the excess to go to waste. I might mention another thing that occurs to me. The water may be used over and over again in the system and, by maintaining a proper degree of acidity in this water, satisfactory results could be obtained.

77 X Q. After adjusting the oil supply from time to time as you have stated you would do, you would not know, would you, whether the amount of oil you were using came within the proportions suggested in the patent in suit or not?

A. I don't think it is necessary that you should know whether they come within the proportions mentioned in the patent. Some of the claims do not specify the quantity of oil. The specification having stated exactly what is to be accomplished and how it is to be accomplished does not limit the exact quantity of oil to be used.

It gives hints in several places as to quantities which have been found suitable, has explained that it is a small quantity and given figures to show how small, but has nowhere undertaken to fix definitely the exact quantity of oil to be employed.

138 The person in charge of the plant, if he understood his business, could judge by the appearance of the froth and the tailings whether the process was going on satisfactorily. If he found it had been going on satisfactorily, he would know that he was using enough of the oil and acid for the purpose. If he feared that he might be using too (126—53) much, he could cut down the supply little by little until he discovered by examining the froth and the tailings that the process was not working satisfactorily.

The object in employing oily matter in the process of the patent is suit is clearly set forth in the specification. It is further clearly stated that, while a great variety of oils and oily substances may be employed successfully, there is a choice among these oily materials which depends upon the character of the ore, and the inventors direct that a simple preliminary test should be made to determine which oily substance is suitable to carry out the process with any particular ore. When the patentees specify, either in the specification or claims 1, 2, 3 and 12, a fraction of one per cent of oily matter, they speak of it in the first three of those claims as oily liquid, and in the twelfth claim as oil, thus providing for a sufficient quantity of any oily substance suitable for carrying out the process of the patent.

In claims 9, 10 and 11 no maximum figure is given for the amount of oil to be employed. The expression is simply "a small quantity of oil," which, as I understand the language of patent literature, would mean a quantity small enough to accomplish the result described and claimed in the patent, the specification of which clearly indicates that, although the quantity may be variable, it is somewhere about one per cent or under.

139

The patentees have selected as the oil to be used in their example oleic acid, and claims 5, 6 and 7 mention this particular oily substance and also mention a proportion which may vary from 0.02 to 0.50 per cent, having evidently found that this is a sufficient margin of variation in quantity and, referring to the specification, I note that (127—54) they state, in speaking of the particular ore which they select for their example, line 96, page 1,

"The minimum amount of oleic acid which can be used to effect the flotation of the minerals in the form of froth may be under 0.1 per cent of the ore; but this proportion has been found suitable and economical."

Claim 1 limits the amount of oil to a fraction of one per cent, while claim 9 limits the quantity of oil only to such a small quantity as will produce the desired froth, which quantity is necessarily variable with different oils and different ores and may in some cases exceed one per cent.

I certainly think it would be desirable, and I think very possibly absolutely necessary, for the proper conduct of the process described in the patent in suit, that the oily body should be in a liquid form,

and if anyone undertook to use a solid oily substance, I think it would be perhaps absolutely necessary that the same should
140 be melted either before or after it is mixed with the ore and water, so that when the mixture is agitated, it will become so finely divided that it may attach itself to the metalliferous mineral to cause the same to produce a froth. I cannot see how it would be possible for a piece of solid fat, like pure stearic acid, for instance, to float about in a tank of water and succeed in producing a film on the minute particles of metalliferous mineral, and, in my opinion, nobody skilled in the art would be likely to select a high melting solid fat to carry out the process of the patent, although he might possibly be able to do it if he tried hard. Of course, I do not mean to say that a piece of solid fat, like stearic acid, a candle end, for example, might not contribute its part to the production of a froth if it has first been ground up with the ore, and thus thoroughly (128—55) diffused mechanically among the particles. When an ore carrying a small quantity of stearic acid introduced in this way is put through the process of the patent in suit along with a suitable quantity of oleic acid, the heat of the warm water would undoubtedly cause the oleic acid to assimilate the stearic acid. The mixture would then correspond to a cheap commercial oleic acid, and would accomplish the result described and claimed in the patent.

Comparing the process set forth in the patent in suit with that set forth in the Cattermole patents, which are referred to in the patent in suit, I should be decidedly of the opinion that the
141 process of the patent in suit would require the most violent agitation, because in that process it is necessary to entrain air into the mixture of ore and water in order to produce a froth, whereas in the Cattermole process no froth is to be produced, the metalliferous minerals are not to be carried to the top of the liquid; on the contrary, it is the gangue minerals which are to be carried to the top, and this is accomplished by an upcurrent of water and not by the introduction of air. I should think that the agitation in the Cattermole process would be likely to be more prolonged.

95 X Q. You have referred to certain preliminary tests recommended in the specification of the patent in suit. Now, assuming that one skilled in the metallurgic art is informed of the fact that, when, under proper conditions, sulphide ores are pulverized and mixed with water, oil and acid, and then agitated, a froth carrying a sulphide is formed, I understand it to be your opinion that a simple preliminary test is all that is necessary to determine the proper proportions of oily matter and acid to produce a froth containing the maximum amount of the sulphides: (129—56) that is, the maximum amount within the commercial requirements. Is this correct?

A. It is. Of course, a person skilled in the art, in attempting to practice the process of the patent in suit, would have the benefit of all the information which is given in the specification of the patent; therefore, he would not be obliged to make random
142 experiments. He would probably start on a new ore by following the directions of the example. If the results are

not satisfactory, he might modify the proportions according to his best knowledge and see if he could improve the results, by varying the proportions of oil or acid or by selecting a different soil from the one with which he first experimented.

I do not know whether the process of patent 835,120 in suit could be used successfully in treating an ore consisting of approximately twelve per cent chalcopyrite, fifteen per cent pyrite, sixteen per cent carbonate of iron, sixteen per cent dolomite and calcite and thirty-seven per cent of other gangue minerals.

In operating with such an ore and using the amount of acid suggested in the patent in suit, the calcite and dolomite present would be likely to neutralize the acid, but, inasmuch as the acid is added simply to facilitate the process and diminish the probability of the gangue mineral appropriating some of the oil, it is not impossible that such an ore might be successfully operated by the process of the patent in suit.

106 X Q. If you found, as a result of experiment in treating the ore last referred to by us, that you succeeded in obtaining a froth, foam or scum containing a large enough percentage of the valuable components of the ore to be commercial, would the operation so performed come within (130—57) the description set forth in the patent in suit?

A. I think it would.

143 No carbon dioxide of any consequence would be generated by the action of sulphuric acid upon the dolomite and calcite contained in this ore, because the quantity of acid recommended by the patent in suit is so small and carbonic acid gas is soluble in water. If a minute quantity of carbonic acid gas should escape, it would not modify the character of the process. The process would still be substantially the process of the patent, because the amount of carbonic acid gas which could possibly be liberated would be practically insignificant as compared with the amount of air which would be forced into the froth.

108 X Q. Is it your opinion as an expert in this art that, if the test referred to by Mr. Nutter were carried out in a bottle, as he describes it, with an ore containing substantial amounts of a carbonate, oleic acid or other oily matters, and a mineral acid such as sulphuric acid being used, the resulting froth, in case a froth appeared, would be caused by the air introduced by shaking the bottle and agitating its contents, rather than by reason of the carbonic acid gas evolved by the action of the mineral acid upon the carbonate?

A. I should infer that, if that experiment were made on the lines of the specification of this patent, that the resulting froth would be caused by the air introduced by shaking the bottle. Mr. Nutter has himself stated that he would make the experiment with or without mineral acid in order to see which set of conditions

144 gave the best result and that he would vary the temperature. (131—58)

109 X Q. Do you consider that the conditions set forth by Mr.

Nutter are within the terms of the specification of the patent in suit?

A. I do; especially considering the fact that this is only a field experiment, made for the purpose of getting preliminary information with regard to the nature of the ore and not for the purpose of regulating the process to be employed in metallurgical works.

It is stipulated that the defendant in the practice of a process of separating the constituents of ores by flotation at Basin, Montana, prior to the commencement of this suit, added sulphuric acid and commercial oleic acid, commonly known as candlemaker's red oil, to the pulp containing the material operated on, but no stipulation nor admission is made as to the quantities of sulphuric acid and commercial oleic acid so used.

Complainants close their prima facie testimony. (132—59)

Testimony Taken on Behalf of Defendant.

Testimony for Defendant of Jesse C. Gibson.

Butte, Montana, April 1, 1912.

Direct examination:

I am twenty-five years of age, and a resident of Butte, Montana. My occupation is storekeeper for the Butte & Superior Copper Company. Previous to becoming storekeeper, I had been for two and a half years a millman for the Butte & Superior Copper Com-
145 pany and was employed by the Butte & Superior Copper Company as an operator at the flotation plant at Basin, Montana, under the direction of Mr. Hyde, the defendant.

Q. 7. State what was used in connection with the operation of the flotation plant.

A. Oil, acid and heat; that was all.

I had charge of the operation of this flotation plant on one shift of eight hours per day from the latter part of July, 1911, until about February 7, 1912.

The Basin flotation plant consisted of a series of agitating boxes and spitzkasten; there were six agitating boxes and three spitzkasten on the first machine; I am not certain as to the number of boxes on the cleaner machine. The pulp entered the first agitator-box, flowed from there to the second agitator-box, from the second to the third and thence into the first spitzkasten. The tailings from the first spitzkasten went to the first agitator-box of the second cell, hence to the second agitator-box, and then to the second spitzkasten. The tailings from the second spitzkasten went to the third cell where there was (133—60) but one agitator-box. The tailings resulting from the last agitation went to the dump. The concentrates from the three spitzkasten described above went to the first agitator-box on the cleaner, thence into the first spitzkasten on the cleaner, the concentrate going to the concentrate-bin. The tailings from the first sptizkasten went to the agitator-boxes on the second cell of the

cleaner, and thence to the second spitzkasten. The con-
146 centrate made on that spitzkasten went to the concentrate-bin. The tailings from the cleaner were returned to the second cell of the rougher to be retreated, the rougher being the first three spitzkasten referred to by me. The acid was fed to the pulp in a launder approximately one hundred feet from the plant previous to entering the settling tanks and the oil was added in the first agitator-box in the first cell. The agitators were propeller-like blades mounted on vertical shafts driven by a belt. I have used the term "cell" as indicating an agitator-box or boxes and the spitzkasten to which the pulp flowed from the agitator-box or boxes. These are commonly referred to as units.

I knew nothing about the so-called flotation process where oil and acids are used before starting to work at the basin plant. I was instructed by Mr. Hyde as to the regulation of the supply of oil and acid, to use oil and acid in such quantity as to produce the best result. I was told that the use of too much oil is indicated by a flat film on the surface of the water, the mineral forming globules and sinking; that too much acid is indicated also by the mineral not floating; that when too little oil is used, there is no separation of the minerals and waste, and that too little acid makes a lower grade concentrate.

The amounts of oil and acid to be used were left entirely to my own judgment. I used oleic oil and sulphuric (134—61) acid, and in operating the plant I did not weigh or measure the quan-
147 tity of oil or acid with a view to using any proportion thereof relative to the amount of ore; and when I operated the flotation plant I had no knowledge of the amount of acid or oil by weight or measure which I was using or the proportion of the same to the amount of ore being treated. I was guided as to quantity by the results obtained and added more or less oil and acid as the need was indicated by the result of the operation. The frequency with which I made changes in the rate of supply of oil and acid varied with conditions, the change being made as often as needed to produce the best results, to wit, high-grade concentrates and clean tailings. It varied greatly, sometimes changes being made so often as every four or five minutes and sometimes not for half an hour.

Heat was supplied to the oil in the oil tank which supplied the machine and in the first agitator-box on the first unit or cell. The oil which I used was a solid mass when received at the plant.

(Mr. Gibson gave substantially the same account of Mr. Nutter's visit to the Basin plant as was given by Mr. Nutter.)

At the time of Nutter's visit, the plant was not operating under normal conditions as to the character of feed. The mill was shut down and the flotation plant was being used to treat concentrates made on vanners, the same being fed into the flotation machine by buckets. The vanners were machines in the mill which treated the slimes. The concentrates procured by Mr. Nutter upon his
148 visit to the Basin plant was not an average grade of concentrate. I could not say at this time whether it was a higher or lower grade. I don't remember what the concentrate run

at that time. It was not a representative sample of the concentrate (135—62) produced by the machine.

During the direct examination, counsel for complainants objected to the description of defendant's apparatus and its operation as secondary and incompetent, with notice that this objection would be withdrawn if opportunity were given to complainants' counsel and expert to inspect the apparatus, and the cross-examination was proceeded with de bene esse, without waiving these objections.

Cross-examination:

The oil was fed to the flotation plant from an oil tank by means of a short pipe having a valve for regulating the supply. I should judge that the capacity of this tank was about twenty gallons.

The acid was fed to the pulp before it entered the settling-tank and approximately one hundred feet from the flotation plant, from a small iron pot or kettle, through a pipe, with a valve. The capacity of this acid pot or kettle was about three gallons. A portion of the water into which this sulphuric acid was fed was wasted or flowed off before the pulp entered the flotation plant in the operation of the settling tank or dewaterer. The dewaterer was under my charge and there was a man stationed there to adjust it under my directions. I do not know what proportion of the water was
149 flowed off or separated in the dewaterer and I do not know what was the proportion of water to ore in the pulp that entered the flotation plant. Before the pulp entered the dewaterer, it had been treated over jigs and tables, where it had been separated and the slimes sent to the dewaterer and settled. (136—63)

When I was instructed by Mr. Hyde as to the operation of the flotation plant, I was shown the appearance of the machine when too much oil was applied and when too little oil was applied, and the appearance when the proper amount was applied, and this was shown to me by the actual operation of the machine. So also as to the amount of acid used, I was shown the conditions which I have described in the operation of the machine.

Redirect examination:

There was a large amount of water in the concentrate coming through the rougher and no water in the concentrate from the cleaner, that is, no free-flowing water.

Recross-examination:

In the rougher machine the level of water was kept at the level of the overflow lip, and in the cleaner machine the level of the water was kept slightly below the level of the overflow lip. (137—64)

150 *Testimony of Defendant James M. Hyde.*

WASHINGTON, D. C., April 24-29, 1912.

Direct examination:

I am thirty-eight years of age, a resident of Palo Alto, California, and a mining engineer and metallurgist by profession. I am the defendant in this suit. I am a graduate of the Department of Geology and Mining of Leland Stanford, Jr., University, in which institution I was instructor for one year in assaying. I was for one year curator of the museum of the California State Mining Bureau, and for three years professor of mining and metallurgy in the University of Oregon. I have worked as a common miner and as a mill-hand in all parts of amalgamating, concentrating, cyaniding and chlorination of mills. I have worked as an assayer and chemist, as superintendent of mines and mills, and as consulting engineer and valuer of mines. I have been a student of processes for the treatment of different ores for the past fifteen years, and am the inventor of the improved process for flotation concentration of ores covered by United States patent No. 1,022,085.

On January 18, 1910, I received the following telegram:

"Can you come London, all expenses allowed in order to see process working and directors. If the directors are satisfied your appearance will offer one thousand pounds sterling and ex-
151 penses for a year in Mexico or elsewhere examination of properties.

"HOOVER.
"Care Mineration."

This cable was sent to me by Mr. T. J. Hoover, who was general manager for Minerals Separation, Limited, one of the complainants. I had not heard from him for some two years' time, but was familiar, in a general way, with the business with which he was concerned, and cabled a reply, stating that I would leave for London as requested, upon (138—65) receipt of an advance sufficient to cover expenses of the trip. The advance was forwarded and I left California about the 28th or 29th of January, 1910, and went directly to London.

The directors of Minerals Separation, Limited, seemed to be satisfied that I was the proper person to undertake an investigation in search of mining business in Mexico, and the directors endeavored to persuade me to make a contract for two years of my time. I declined to make a contract for more than one year, because I did not desire to be separated from my family for long periods; for the reason also that the Assistant Secretary of Education for the Republic of Mexico had requested me to hold myself in readiness to undertake, as soon as opportunity could be arranged, the outlining and development of a system of industrial education for the people of Mexico, and I desired to avail myself of this opportunity. I did not wish to contract for more than a year because a year's employ-

ment might indicate to both parties that it was not wise to
152 continue our relations, and also because during the year I would come into possession of an inheritance which would permit me to operate independently.

While the contract matter was under discussion, I visited the test works of Minerals Separation in London and was shown the methods by which small and larger lots of ore were tested by the processes practiced by the company, and I also made a trip to Wales to witness tests upon the ore of the San Francisco del Oro mine of Mexico which had been shipped to England. The tests were not very instructive, as Mr. Hoover and the attendant in charge informed me that the results being obtained were very unsatisfactory. Upon my return to London I came to an agreement (139—66) with the board of directors to enter their employment for one year's time. The chairman, Mr. John Ballot, addressed a letter to me dated March 2, 1910, which reads in part as follows:

"James M. Hyde, Esq., 62 London Wall, E. C.

DEAR SIR: As explained to you a private syndicate has been formed in connection with my company for the special purpose of exploring the Republic of Mexico, with a view to finding mines, ores, dumps or tailings, preferably amenable to profitable treatment by the Minerals Separation processes, and to endeavor to
153 acquire such mines, ores, dumps or tailings, wholly or in part, if such can be done on sufficiently advantageous terms, or to secure the adoption of Minerals Separation processes by mine owners, under royalty, in cases where a direct interest cannot be acquired—and if successful, to form a larger company to handle the interests so acquired.

To give effect to this, and after fully discussing the policy with your goodself, it has been agreed to retain you to give your services exclusively, to make the necessary investigation in Mexico, and to carry out the object and intention of the syndicate to the best of your ability on the following terms and conditions:"

Then follow the terms and conditions as shown by the letter which I now produce.

To quote further from the letter:

"For the purpose of this understanding and to enable you to test ores on the spot, Minerals Separation will disclose to you its various processes, and give you all information in connection therewith, you undertaking to keep all such information confidential, and not to make use of any of it for any purpose except that of the syndicate, and further you undertake and agree to communicate to that company any ideas for improvement, modification or addition to the processes, mechanical or otherwise, which may occur to you, or which you may make, and such shall be the sole property of the Minerals Separation, and you will immediately, or whenever
154 called upon, sign all documents necessary to protect the same by patent, if so desired, and to convey the title to that company by assignment or otherwise."

(The documents referred to produced by the witness were marked for identification, respectively "Cable, Hoover to Hyde, January 18, 1910," (140—67) and "Letters, Minerals Separation to Hyde, March 2, 1910," and they were later offered in evidence by the complainants with the same titles.)

At the testing works of Minerals Separation in London, I was shown the bottle test referred to by Mr. Nutter in his testimony, and I recognized the bottle test to be the exact test given by Alcide Froment in his British patent No. 12,778.

I also was shown certain tests which were conducted by agitating finely pulverized ore, water, sulphuric acid, and some oily substance in a rectangular wooden box having two glass sides, the agitator consisting of a vertical shaft suspended from above and within the vessel. When the agitation was completed, the mass was allowed to come to a rest, whereupon a considerable amount of froth could be seen upon the surface. The material was then reagitated while the contents of the vessel were drawn out through an aperture at the bottom and spread out upon the apron-plate of an overflow settling-box, the oiled mineral matter floating off as a surface film, while the gangue and some of the metalliferous mineral sank to the bottom and was drawn off and retreated upon a device similar to the one from which it was drawn.

155 Mr. T. J. Hoover, general manager of the company, told me that this test did not represent the processes as actually operated by the Company, but was the closest approach to it which they had been able to devise on a small scale, and asked me to co-operate with him in devising a form of apparatus which would give results duplicating those obtained in the frothing process as developed in Australia, so that I might have a machine with me by which could be duplicated the results to be expected of the frothing (141—68) process, as developed in Australia. Together we designed a machine similar to, and probably the same as, the machine referred to as the slide test machine by Dr. Chandler and Mr. Nutter in their testimony. I had several of these machines built in London and remained in the city long enough to develop a system of tests by the use of this apparatus and to instruct Mr. Wilkinson, an attache of Minerals Separation, in the use of this apparatus.

In connection with the designing of the slide machine, after Mr. Hoover and I had discussed many possible modes of introducing a sheet of metal or hard rubber or something of that sort through a side opening in a vertical agitating box in such a way as to divide the machine into an upper and a lower part, after pulp had been agitated in it, so as to allow the top water and float concentrates to be drawn off through an opening in the side of the machine above the inserted horizontal partition, Mr. Hoover suggested that it should be possible to divide a machine into an upper and a lower por-

156 tion and slide off the upper portion over a proper guide, as was finally done in the machine which we evolved. We discussed the matter together, making several sketches, details of each being contributed by each of us, and finally decided upon the form

which was finally constructed. Such computations as to size as were necessary were made by me.

The machine as originally designed was constructed under my supervision, was tested by me and was modified under my supervision in a number of minor features after the first tests were made. The machine was constructed by Mr. Dearden, a model-maker and machinist, in London. I had several of these machines built in London and remained in the city long enough to develop a system of tests by the use of this apparatus and to instruct Mr. Wilkinson, an attache of Minerals Separation, Limited, in the use of this apparatus. I proceeded to the United States and thence to Mexico and devoted the year to a search for such (142—69) properties as might be worked to a profit by the Mexican Syndicate.

The apparatus designed by Mr. Hoover and myself was so arranged that when a material had been sufficiently agitated to oil the metalliferous matter, agitation ceased, and the oiled mineral matter with gas bubbles attached floated and was removed as a floating froth by sliding off the top half of the machine and discharging its contents into some receptacle.

I completed my year's employment with Minerals Separa-
157 tion, Limited, and immediately after leaving the employ of Minerals Separation, Limited, I accepted an appointment as consulting engineer for the Oroya Exploration Company with offices at No. 1 London Wall Bldgs., London. The health of my only child prevented my wife and child from coming to London and therefore I planned to come to the United States at the earliest opportunity.

For years prior to entering the employ of Minerals Separation, Limited, I had made a close study of the technical press upon ore treatment.

Q. 9. At the time you entered the employ of Minerals Separation, Limited, or while so employed, did you make any study of the patent situation from the legal point of view?

A. As my time was devoted to the search for material which could be acquired by purchase, lease or otherwise, I gave very little study to the legal phases of the situation. I remember having read some part of the record of the suit filed against Minerals Separation, Limited, by the Elmores.

Q. 10. Did your duties while employed by the Minerals (143—70) Separation, Limited, require you to be conversant with the patent protection which they might have or were going to have?

A. They did not. They made very broad claims to me as possessing monopolistic rights for the use of all flotation processes which involved the use of small amounts of oil, but, as I was specifically warned by them against seeking royalty business, except as a last resort, I never had occasion to prepare myself to defend their
158 rights in matters involving infringement of patents, etc.

After leaving the employ of Minerals Separation, Limited, in order to assure myself of the actual status of the patent situation in regard to flotation processes, I read over all of the patents relating to this subject which I could get access to, and made as careful study as possible of the subject matter covered by them, and arrived at the

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conclusion that the only significant patents were the Everson United States patent 348,157, Fromen British patent 12,778 and the Elmore vacuum process United States patent 826,411. To my mind the whole basis of flotation concentration was disclosed in the Everson and Froment patents.

The only definite instructions given me by those connected with Minerals Separation, Limited, regarding the practice of the oil flotation process was that a preliminary idea could be obtained by making the bottle test and by carrying out a series of tests in the slide machine. I was not instructed in detail with regard to the use of large testing machines further than that in all cases it is necessary to run varying the conditions as to amount of oil and acid used until such quantities were determined upon as gave the best results. I was informed by the (144—71) engineer of the company that apparatus of the type shown in the illustration of the patent in suit had proven unsatisfactory and had been abandoned. While in the employ of Minerals Separation, I did not see any commercial operations
159 carried on in which any process owned by that company was used.

Toward the end of my year's employment by Minerals Separation, Limited, I received a communication from the chairman of the company asking me to undertake work outside of Mexico. I declined this work because it would require more time than the remainder of the year contracted for. I was thereupon requested to go to London and did so, arriving there a day or two before Christmas, 1910. There were negotiations between me and the company in London which, however, resulted in my concluding to sever my connection with the company. I was asked to outline a plan upon which we could work together for a greater length of time, being told that an American Syndicate had been formed to carry out such a search for business upon the whole American continent, as had been undertaken in Mexico by the Mexican Syndicate. I submitted a memorandum outlining such plan which was considered by the members of the board of directors and discussed with me in particular by Mr. Francis Gibbs, Jr., one of the directors. A discussion of this matter was going on, with all probability that I should enter into another contract with the firm, when I determined that it was not wise for me to continue longer with them, withdrew the memorandum referred to, and handed in a letter formally severing my connection with the firm.

(The witness here produced the correspondence referred to and the several documents were marked for identification, respectively,
160 "Letter, (145—72) Minerals Separation to Hyde, November 23, 1910"; "Cable, Minerals Separation to Hyde, December 8, 1910"; "Cable, Hyde to Minerals Separation, December 9, 1910"; "Copy Memorandum re the Managership of Minerals Separation American Syndicate, Limited"; "Letter, Minerals Separation to Hyde, February 1, 1911"; and were later offered in evidence by complainants with the same titles.)

I was influenced in my determination to leave the employment of

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Minerals Separation, Limited, by a misunderstanding between that company and their consulting engineer and manager, Mr. T. J. Hoover.

I never told Mr. Edward H. Nutter that I accepted employment by Minerals Separation, Limited, for a year only in order to be free at the end of that period to make a more favorable contract with the company or else to make use of my knowledge of flotation concentration for my own purposes.

About the first of March, 1911, I accompanied Mr. H. C. Hoover, with whom I was associated in the Oroya Exploration Company, to the United States. Mr. H. C. Hoover was offered a participation in a bond issue which was being considered by Hayden, Stone & Company for the Butte & Superior Copper Company, and at Mr. Hoover's request I accompanied a Mr. Kuehn to Butte, Montana, to examine the property and to make tests of the ore to determine the best method of treatment. Mr. H. C. Hoover asked me to determine whether the Butte & Superior ore was amenable to a flotation process.

I had a slide machine made at Butte and reported the result
161 of my tests to Mr. H. C. Hoover. The manager of the Butte & Superior Copper Company asked for a report of my tests, but I replied to the effect that I could report only to (146—73) Mr. H. C. Hoover. Later Mr. Hoover informed me that he was not going to participate in taking up the bonds to be issued by the Butte & Superior Copper Company and I made a report to the Butte & Superior Copper Company and was requested to and did install an experimental machine for that company at Basin, Montana. This machine was first operated about the first of August, 1911. After this test machine had proven that the new process which I had worked out could be successfully employed, a larger machine was built and this one was abandoned. The machine is not now in existence. The machine was operated intermittently for between one and two months. The machine was destroyed for the reason that the space was needed for other purposes.

I produce a sketch of the experimental machine at Basin. (The sketch is in evidence as "Defendant's Exhibit, Hyde Sketch of Experimental Machine.")

The plant consisted of two parts, a machine known to the operators as a rougher machine, and generally designated on the sketch as R. M., and a se-ondary or cleaning machine designated on the sketch as C. M. The rougher machine consisted of six agitating compartments and three overflow settling-boxes. Five of these agitating com-
partments were built together in the form of a rectangular
162 box divided by partitions into compartments. To this box were attached two of the overflow settling-boxes. The remaining portion of the rougher machine consisted of one rectangular agitating compartment, connected with an overflow settling-box. In each of the agitating compartments an impeller suspended and attached to a vertical shaft was provided to act as an agitator. The cleaner machine consisted of four agitating compartments and two overflow settling-boxes. Three of the agitating compartments were built together in the form of a rectangular box, divided into three

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sections by partitions. (147—74) To this box was attached one of the overflow settling-boxes. The remaining portion of the cleaning machine consisted of one rectangular agitating compartment connected with an overflow settling-box. In connection with the concentration machine proper, two pulp thickening tanks were used, in which the pulp to be treated was separated from as much clear or nearly clear water as possible, in order to prepare it for flotation treatment.

Referring to the sketch, I will trace the passage of the ore through the pulp thickeners and machine. The material to be treated, which consisted of fine portions of the ore removed by classifiers from that portion of the ore which was treated by other devices, flowed to the pulp-thickeners through the thin pulp launder marked T. P. L. to the plup-thickener designated as P. T. A small amount of sulfuric acid was added to the pulp as it flowed to the pulp-thickener from the acid-pot, A. P., by means of a pipe, the flow being regu-
163 lated by the acid-valve A. V. The thickened portion of the pulp, which was to serve as feed for the flotation machine, was drawn off from the bottom of the pulp-thickeners by the feed-valves F. V. and F. V.′, and flowed to the flotation machine through the feed launder F. L. The clear, or nearly clear, water flowed off to waste over the end of the pulp thickener marked C. W. O. The feed launder F. L. discharged the ore to be treated into the agitation compartment A^1. Into this compartment live steam was discharged through the steam-pipe S. P., and red oil was fed from the oil-pipe O. P. The pulp, after being agitated in A^1, flowed through an aperture into A^2, in which it was further agitated, and from which it flowed through an aperture into A^3, in which it was further agitated. From A^3 the pulp flowed through a practically square (148—75) opening into the settling-box designated as S. B.¹ This settling-box was so attached to the box containing the agitating compartments that the partition dividing A^3 from A^4 was opposite the center of the settling-box. Over the discharge lip of the settling-box S. B.¹, floating metalliferous minerals with considerable free-flowing water containing gangue minerals overflowed continuously into the launder marked R. C. L. That portion of the pulp which was not drawn over the di-charge lip into the concentrates launder flowed from the overflow settling-box through the valve V to a pipe leading to a pump marked Pump 1, by which it was elevated and discharged into
164 the agitating compartment A^4, in which it was agitated further, and from which it flowed into the agitating compartment A^5 for further agitation. From A^5 it flowed through the square opening into the settling-box S. B.², from the overflow lip of which the floating metalliferous matter with considerable free-flowing water containing gangue minerals was continuously discharged into the rough concentrates launder. Through the valve V′ that portion of the pulp which was to be further treated was discharged into a pipe, through which, by means of an hydraulic elevator and by force of gravity, it flowed into the agitating compartment A^6, from which, after agitation, it was discharged through a practically square aper-

ture into the overflow settling-box S. B.[3], from the discharge lip of which was discharged the last portion of the concentrate recovered from the ore, together with a considerable amount of free-flowing water carrying gangue minerals in suspension. By means of the valve V″, the tailings were discharged to waste. The concentrates drawn off over the discharge lips of the settling-boxes of the rougher machine flowed to a pipe, through which (149—76) they were forced into the first agitator compartment A[7] of the cleaner machine by an hydraulic elevator. After agitation in A[7] they passed through an opening into A[8], and thence on to A[9], being agitated in each of these compartments, and flowed through a practically square opening into the settling-box S. B.[4]. Upon the surface of the water in this overflow settling-box, the concentrates piled up as a tenacious froth
165 3 or 4 inches thick. The water in this settling-box was maintained at such a level by the manipulation of the valve V‴ that no free-flowing water overflowed from it, but the concentrates piled up and flowed over the discharge lip as a thick mass into the clean concentrate's launder C. C. L. A portion of the material which was not drawn over the discharge lip was passed on to the agitating compartment A[10] through the valve V‴, and a pipe through which it was forced by an hydraulic elevator. After being reagitated in A[10], the material passed through a practically square opening into the settling-box S. B.[5] When the amount of concentrates forming upon the surface of the water in S. B.[5] was sufficient to allow the semi-dry concentrates to be drawn off over the discharge lip without any free-flowing water, they were so drawn off as from S. B.[4] When the amount forming was too small to allow this, no concentrates were drawn off over the discharge lip, the whole content of the machine being discharged through the valve V[4] into a pipe, through which it was forced by a steam jet to pump 1 and returned to agitating compartment A[4] for further treatment. The concentrates produced by the cleaner machine flowed through a pipe to pump 2, by which they were discharged into the shipping bin.

In operating the experimental machine at Basin, the amounts of oil were determined at all times by an observation (150—77) of the results obtained and by varying the flow of acid and oil in
166 such way as to give what appeared to be the best results.

Q. 36. Have you ever found any better means of regulating the amount of acid and oil than by an observation of the results secured?

A. I have never found any other means which can be made use of.

I met Mr. Edward H. Nutter in Montana on two different occasions, or rather at two different periods. While engaged in making the examination of the Butte & Superior property with Mr. Kueha I met Mr. Nutter in Butte on a number of occasions, and later me him at Basin. On both occasions he informed me that he was then as a representative of Minerals Separation, Limited, or Mineral Separation American Syndicate, Limited.

Q. 40. When in England, in the employ of Minerals Separation, Limited, did you witness any tests made with a large testing apparatus owned by Minerals Separation?

A. I saw the tests which have previously been referred to as being made in South Wales. The large test machine in the London works was not being used at the time of my first visit to England, because of alterations which were being made in the plant. During the period of my second visit to England tests were being carried on in a special machine devised by Mr. Nutter, which machine I saw in operation one or more times, but I was informed that its results were not entirely satisfactory.

Q. 43. You have referred to a U. S. patent upon a flotation
167 process. When and how did you come to invent the process described in this patent?

A. I take it that you refer to U. S. patent 1,022,085, and shall formulate my answer accordingly. (151—78)

While engaged in making tests upon small quantities of the ore of the Butte & Superior Copper Company in the small test apparatus which I had made at the foundry in Butte I was surprised to find that the concentrates obtained were not of as high a grade as I had anticipated from a careful study of the ore. I therefore examined the concentrates and found that they contained an apparently considerable amount of free gangue particles. The thought occurred to me that if the froth which was first formed was retreated by itself, it would be possible to disentangle and drop out a considerable portion of this worthless material. I therefore took the froths obtained from the treatment of a portion of the ore and after cleaning out the small test machine returned these froths to the machine, together with a sufficient amount of water, and reagitated the mass thoroughly. The bulk of the metalliferous mineral again floated and, upon assay, was found to be of higher grade than the concentrates which had been produced by the procedure which I had previously followed. I followed this matter up and found that whereas the concentrates produced without retreatment would contain from 48 to 51 per cent of zinc, it was possible to raise the grade by retreatment in the small test machine to as high as 55 per cent.
168 Consequently, when I came to build a test machine at Basin, I planned for a machine consisting of a rougher and cleaner, and planned to use the rougher to make as complete a recovery as possible, and the cleaner to raise the grade of the concentrates as high as possible.

When this machine was installed it was soon apparent that the best way to achieve the results desired was to maintain such an overflow of concentrates and free-flowing water over the discharge lip of the overflow settling boxes (152—79) of the rougher as would insure the complete and rapid removal of all metalliferous mineral matter which rose to the surface of the water. This involved the overflow with the concentrates of a considerable amount of suspended gangue matter. The concentrates on the surface of the overflow settling-boxes of the rougher machine were usually thin and light colored. It was found possible to pile up the concentrates upon the surface of the water in the overflow settling-boxes of the cleaner machine to such a depth that the water-level could be kept so low that there was no free flow of water over the discharge lip but a constant

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or intermittent sloughing over of a thick froth of cleaned concentrates. It was soon apparent that the tailings resulting from the cleaning operation were too valuable to be thrown away and an arrangement was consequently made by which they could be carried back to the rougher machine and further treated.

As it was found very difficult under the conditions met at
169 the mill to produce a pulp sufficiently thick to be advantageously treated, the thought occurred to me that sulfuric acid might advantageously be made to act as a coagulant of the slimes in the pulp-thickener, and thereby perform a useful and added function. This was tried and was found successful. The process as covered by the patent was therefore largely developed in the course of these experimental operations, the matters of manipulation, etc., being learned during the first few days in which we worked.

Q. 44. What is the composition of the ore of the Butte & Superior mine which you have treated by a flotation process of separation?

A. The ore varies so much in its content of its various constitutents that it is impossible for me to give you (153—80) a chemical analysis which would be typical of the whole mine. Mineralogically, the ore consists of zinc blende, a small amount of galena, varying amounts of pyrite and copper minerals, which are usually very small in quantity, quartz, altered granite, in which most of the felspars are kaolinized, and rhodonite and rhodochrosite (respectively the silicate and carbonate of manganese). The principal value of the ore is due to its content of blende or zinc sulfid.

Q. 45. In your experiments with the Butte and Superior ores have you made any observations of the quantity of oleic acid or other oil used in different experiments, and if so, with what result?

A. I have experimented in my small test machine, using
170 500-gram charges of ore with amounts of oil varying from .6 of 1 cc. to 9 cc., getting very satisfactory results with both the smaller and larger amount of oil, the oil referred to being the impure oleic acid or red oil used in the experimental plant at Basin.

A typical test with the use of a very small amount of oil gave results as follows: The pulp treated was a sample of ore from the mill which assayed 23.3 per cent zinc; the concentrate obtained from treating a 500-gram portion of this ore weighed 204.9 grams and contained 52 per cent of zinc; the tailings weighed 283.5 grams and contained 2.2 per cent of zinc. This test was carried out in the slide test machine, using 2 cc. of a 50 per cent solution of sulfuric acid and .65 cc. of oleic acid. The actual recovery of zinc in this case amounted to 91.4 per cent. As the specific gravity of the impure oleic acid used is approximately .9, the actual weight of impure oleic acid used was .585 gram. This is equivalent to 2.34 pounds per ton of ore. (154—81)

In a test in which 500 grams of ore containing 20.3 per cent of zinc was treated in the small test machine with 9 cc. of oleic acid, 1 cc. of concentrated sulfuric acid and approximately 1700 cc. of water at a temperature of 78° Fahrenheit, 217 grams of concentrates containing 46.5 per cent of zinc were obtained, and 283 grams of tailings containing .6 of 1 per cent of zinc. The weight of im-

pure oleic acid used in this case was 8.1 grams, equal to a rate of 32.4 pounds per ton of ore. This is equal to 1.62 per cent on the
171 weight of the ore or 5.3 per cent of the weight of the metalliferous mineral contained in the ore. The percentage of recovery of zinc in this test amounted to 99.4 per cent as figures from the weight of concentrates and their assay value and as 98.4 per cent when figured by subtracting the total zinc content of the tailings from the total zinc content of the portion of ore treated.

All assays quoted by me in discussing these tests were made by W. H. Hocking, of Butte, Montana.

I have tested the ore similarly with cotton-seed oil, using a sample which I obtained from the Fair Drug Company, of Butte, Montana, and getting phenomenally high recoveries with amounts varying from .27 of a gram to 18 grams per charge of 500 grams of ore or through a range of from 1.08 to 72 pounds per ton of ore.

Using .3 of 1 cc. or .27 gram of cotton-seed oil in treating a 500 gram charge of ore containing 21.3 per cent of zinc, I obtained concentrates assaying 50.6 per cent zinc and tailings assaying 1.3 per cent zinc. The percentage of recovery as figured by formula was 96.3 per cent.

Using 5 cc., of 4.5 grams, of cotton-seed oil in treating 500 grams of ore of the same lot, I obtained concentrates (155—82) containing 45.4 per cent zinc and tailings containing .8 of 1 per cent of zinc, the indicated recovery being 96.5 per cent.

Using 10 cc., or 9 grams, of cotton-seed oil in treating 500 grams of ore of the same lot, I obtained concentrates containing 49.5 per cent zinc and tailings containing .7 of 1 per cent of zinc,
172 the indicated recovery being 98.1 per cent. The amount of oil used in this case was equal to 5.6 per cent of the weight of metalliferous mineral present in the parcel of ore.

Using 20 cc., of 18 grams, of cotton-seed oil in treating 500 grams of ore of the same lot, I obtained concentrates assaying 51.5 per cent of zinc, tailings assaying 1 per cent of zinc and an indicated recovery of 97.2 per cent. The amount of oil used in this test was equal to 11.2 per cent of the weight of metalliferous minerals in the ore treated.

All of these tests with cotton-seed oil were made upon a sample of ore containing 21.3 per cent of zinc. In each test 1 cc. of pure sulfuric acid was used, and, in all cases, the concentrates were recovered as a froth.

By Mr. Williams: It is noted that the tests above described by the witness not having been made in the presence of opposing parties, the observations and conclusions of the witness are objected to as not the best evidence, unless an opportunity is afforded to complainants to repeat these experiments by supplying the complainants with sufficient quantities of the ores used in the conditions in which they were used in these experiments, and also, if necessary, of the other reagents. With this reservation, no objection is (156—83) made to the assay figures upon the ground that the man who made the assays is not produced as a witness.

When I commenced to test the Butte & Superior ore, I investigated the sources of oil supply, and the only oil produced in
173 the vicinity was that made by Charles T. Perry & Company, of Helena, Montana, at their soap and candle factory. I obtained samples of Perry & Company's red oil and also samples from other companies, and determined that Perry's red oil was more satisfactory than other materials available. It is the only oil produced in the Rocky Mountain region, with the single exception of some petroleum products, which do not give as commercially successful results.

In the vicinity of the pulp-thickeners and the flotation machine a decided odor of hydrogen sulfid was evident, which I attributed to the re-action of sulfuric acid upon the zinc sulfid in the ore.

Perry & Company delivered oleic acid to us in drums or barrels, the oleic acid always being in a solid or semi-solid condition. I have never seen a barrel opened in which the oleic acid was sufficiently fluid so that the whole content of the barrel could be poured out through the bunghole. I therefore heated it and brought it into the fluid condition necessary in order to use it in the flotation process.

I do not know of any process of oil concentration which is universally applicable to all sulfid ores. I have attempted to work out a successful method of treatment of ores containing very finely-divided chalcocite, copper sulfid, without being able to get commercially useful results. Many sulfid ores containing sulfids of lead, zinc, (157—
84) iron and copper could be made to yield tailings very free from sulfid, but the resulting concentrate containing the differ-
174 ent sulfids mentioned is scarcely, if any, more easily marketable than the crude ore from which it has been concentrated. There are very few ores which can be successfully treated by oil concentration alone.

Cross-examination de bene esse, not waiving objections and notices heretofore stated and given:

I am paying the expenses of the defense of this suit with the exclusive right to use in the Butte district the process covered by my United States patent No. 1,022,085, that exclusive right being granted to the Butte & Superior Copper Company for such sum of money as is necessary to cover the expenses involved in the defense of this suit.

X Q. 72. From the letter marked for identification "Letter Minerals Separation to Hyde, November 23, 1910," which you have produced, I quote the following:

"After attending to the above matters, please proceed to Butte, Montana, and there go into the Zinc situation with the same minute care which has attended your investigations of the various fields in Mexico. Also test the tailings and various products you can secure from the copper mines and mills, say as little about your connection as is considered with getting information."

Was not the Butte & Superior Copper Company an important element of the zinc situation in Butte, Montana?

A. To the best of my knowledge and memory, the name of the

Butte & Superior Copper Company has never been mentioned
175 to me by anyone connected with Mineral Separation, Limited. I do not doubt that they knew of that property and of Senator Clark's adjoining property, from which zinc concentrates were being shipped to Beer, Sondheimer & Company for treatment, through Beer, Sondheimer & (158—85) Company who were associated with them in the Mexican syndicate, in whose behalf I had been retained to give my services for one year exclusively in searching for ventures in Mexico. These two properties are an important feature of the zinc situation at Butte.

X Q. 73. As a matter of fact, the mines at Butte are principally copper, and the two properties that you have mentioned are about the only zinc mines. This is true is it not?

A. The properties which I have mentioned are the most important producers of zinc in the Butte district, in which, until the last year or two, no attempt had been made on a large scale to make use of the zinc ores which occur in great quantity in a number of properties. In the Butte & Superior mine and Senator Clark's Elm Orlu mine, which is the mine I have referred to in my answer to the previous question, the zinc ore is of greater purity than in other parts of the district, but in one section of the district I understand that practically all of the mines contain considerable zinc, and I am informed by the officers of the Amalgamated Copper Company that many of the large copper producers contain notable amounts of zinc-bearing ore of such grade that they should ultimately be large contributors to
176 the zinc output of the camp. It is my private belief that Butte will eventually become as important a factor in the zinc industry of the country as it is now in the copper industry.

(Witness identifies the letter described by him as delivered to Minerals Separation American Syndicate, Limited, in severing his connection with that concern, and it is marked for identification "Letter, Hyde to Minerals Separation American Syndicate, January 17, 1911." It (159—86) was later offered in evidence by the complainants with the same title.)

My equipment for testing ores while in Mexico included one or more slide machines sent to me from London and such small motors as I was able to make use of in places where I worked. It is my recollection that I made bottle tests such as I have referred to while in Mexico, although I have never, while with Minerals Separation, made very many tests of that type, as I had the means at hand for doing quantitative work. With proper manipulation, such a bottle test is practically absolutely conclusive as to whether or not the sulfid contents of an ore could be made to float. This test was held in so high esteem by Minerals Separation, Limited, that T. J. Hoover, their chief technical adviser, assured me that it was useless for me to burden myself with heavy test apparatus, because the bottle test would always give an indication of what could be done with an ore, and it was a safe guide, as to whether or not an ore tested by it was worthy of further investigation and that it would be
177 saving of time to rely upon the London test works to make all quantitative tests, but, in deference to the wishes of the Board

of Directors that I should be able to report as to quantitative results obtained in the field, we considered it worth while to devise and make field use of the slide test machine.

X Q. 88. In the flotation separation apparatus used by you at Basin, Montana, what percentage of sulfuric acid was employed in the pulp solution which was fed to the first agitating-box?

A. I have no absolutely definite information upon this point.

X Q. 89. What was the consumption of sulfuric acid per ton of ore treated, on the average? (160—87)

A. I never had any absolutely reliable information as to the exact tonnage of ore which was being treated, and can therefore not give absolutely reliable information with regard to the average consumption of sulfuric acid per ton of ore treated.

X Q 90. Is it not a fact that the cost of the sulfuric acid is an essential element in determining the commercial value of such a process as you used?

A. It is, but the conditions under which the operations were carried out at Basin were such that it was not possible there to determine the actual commercial value of the process as practiced.

X Q. 91. What is your present knowledge as to the cost or consumption of sulfuric acid per ton of ore in this process?

178 A. From reports prepared by Mr. Smith, who was taking samples while tests were being run with the experimental machine, it was indicated that the consumption of sulfuric acid amounted to from a quarter to a half-pound per ton of ore treated, when it was used in the particular way indicated in my patent and practiced at Basin, that is, by being added previous to the thickening of the pulp.

The reason I have referred to the information as not absolutely reliable was because the calculations as to tonnage were based upon the weight of quart samples of the feed pulp which were taken from time to time, as was also the number of gallons per minute flowing through the plant. The percentage of solids in the feed was determined by reference to a chart prepared by Smith, giving the percentage of solids in a quart of pulp for different weights of the quart of pulp. The chart and method have since been demonstrated to be so unreliable that no common factor even can (161—88) be used for corrections of its errors and the reports based upon such observations are so inaccurate as to be unworthy of consideration as evidence.

X Q. 96. I take it that you have no doubt that the pulp which was fed to your flotation plant and entered the first agitation box thereof contained less than 1 per cent of sulfuric acid?

A. It is probable that it did not contain more than 1 per cent.

X Q. 97. It seems to me a reasonable conclusion that it contained much less than one per cent of sulfuric acid. Do you

179 agree with me as to this?

A. It is reasonable to so assume, but, as the amount of acid used in proportion to the ore treated was not accurately determined and was sufficient to cause such a reaction upon the ore as to make the odor of hydrogen sulfid apparent both at the pulp-thickeners and in the flotation plant, I would not feel justified in committing myself

to any definite conclusion as to what amount was used in proportion to the amount of water or ore.

X Q. 98. What became of the sulfuric acid in the overflow from the thickener in which sulfuric acid was added to the pulp?

A. It passed off with the overflow water which flowed to waste.

X Q. 99. Referring now to the typical test first described by you in your answer to Q. 45, at what temperature was this test conducted?

A. I have no record of what temperature at which this test was made.

X Q. 100. What is your best recollection? (162—89)

A. My best recollection is that while making the series of tests of which this is one, it was my custom to put into my machine the hottest water which was available, which was frequently at almost boiling heat, but which would be cooled by contact with the machine to a temperature of approximately 60-65° centigrade. As this practice was not always followed, and I was performing many tests, I cannot say that I have any definite memory as to the conditions of temperature under which this test was made.

180

X Q. 101. You say that you used a sample of ore from the mill. Please more definitely describe the sample which you used?

A. My note-book bears the following record as a title to this test: "Slime Table Heads plus alum, four days." My recollection is that this is material which was collected over a period of four days' time as a sample of the material being treated by the Wilfley tables which were treating what was called a fine feed. This was the material which was later used as the feed for the flotation test machine. The reference "plus alum" refers to the fact that a very small amount of alum had been added to the pulp, as collected, in order to settle the slimes so that clear water could be turned off, and it would not be necessary to dry down the whole sample which filled several half barrels. My tests have indicated to me that the use of alum in this way does not disadvantageously affect the results to be subsequently attained in treating ore by a flotation process.

X Q. 102. Continuing my reference to the physical test first described by you in your answer to Q. 45, please supplement your description, more particularly as to the speed of rotation of the agitator blades, the diameter thereof, and the period of time and the number of times the agitation was carried on, and any other particulars that may be necessary (163—90) in order to reproduce this test.

A. I have no description in my notes of the exact dimensions of the test machine used, but, from memory, would state that the approximate width of the slide machine was probably 4 or 5 inches, the probable diameter of the impeller, 3 or 3½ inches. The impeller was a simple, cross-like metal agitator having two cross-arms attached to a hub. These arms had a height of approximately one-half inch and a thickness of not over probably an eighth of an inch. This impeller was attached to a

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vertical shaft introduced into the agitating chamber through a stuffing-box or gland in the bottom of the agitating-box, and was driven by an electric motor, power being transferred to it by a small belt. I have absolutely no record as to the speed, it never having been determined, and having varied through a considerable range at different times, because the motor was upon a movable block or board, and the belt frequently ran so loose that the full speed was not transmitted to the impeller. The agitation was brisk.

In most of the tests of the series from which this one is taken, the pulp was agitated for from twenty to forty seconds, when it was allowed to come to rest, and after the gangue material had settled sufficiently to show clear water through the window in the side of the machine, the concentrate floating in the upper portion of the machine was removed by sliding the upper half of the machine forward and emptying its contents into a pan. The upper portion of the machine was then pushed back into position, clamped into place, and sufficient water added so that about a quarter of an inch
of water was visible through the window in the upper half
182 of the machine. The operation of agitation (164—91) and removing of froths was repeatedly performed so long as a material amount of concentrate was produced by each operation. The time of agitation was as before. Usually but two portions of concentrate were removed, a third agitation rarely giving enough added concentrate to be of consequence.

I believe that the manipulation just described was that by which the results cited in the test referred to were obtained. There is no record in my note-book describing this test more fully than to give a description of the material treated, the weight and assay value of the ore used, and the concentrates and tailings resulting from the test, the numbers which were attached to these when sent to the assayer, and the percentage of recovery indicated.

From memory I would state that the material treated was very fine—would all pass through a 60-mesh screen, most of it being fine enough to pass through a 100-mesh screen.

X Q. 103. You have not, in your description, stated the amount of water used originally in this experiment. What was this amount?

A. Approximately 1,700 cc.

X Q. 104. Now, referring to the second test described by you, in which you used 9 cc. of oleic acid, please supplement your description by such particulars as would enable us to reproduce the test.

A. The manipulation in this case was practically identical with that described in my preceding answer. The note-book con-
183 tains this additional data: "3 froths, 1 film obtained. Result excellent." The oleic acid used in this case, I remember to have been from a sample of purer red oil which Charles T. Perry & Company, of Helena, Montana, had submitted to me in response to a request to (165—92) submit sample of oleic acid or red oil with the lowest melting point which they could produce in commercial quantities.

The red oil used in the test just previously described was from

a sample of impure oleic acid, which they have regularly produced and marketed under the name of "red oil." This was the material used as oil in the test carried on with the experimental machine.

X Q. 105. Will you send me a specimen of each of these varieties of oleic acid used by you in these experiments?

A. I will arrange to have it sent to you from Butte.

X Q. 106. And will you also send me a specimen of the ore used in these experiments in the condition in which it was used therein?

A. I will arrange to have this duplicated, as nearly as possible, for you.

X Q. 107. Now, as to the test wherein you used 0.3 cc. of cotton-seed oil, please supplement your description by such particulars as will enable us to reproduce this test?

A. The series of tests with cotton-seed oil were all carried out substantially as has been described in my answer to X Q. 102. I have no record in my note-book, and cannot state from mem-
184 ory definitely, as to the period for which the pulp was agitated in these tests, but my memory is that it was from twenty seconds to a minute. It may have been even more than a minute.

The amount of water used was approximately 1,700 cc., the water was warm, but I have no record of its temperature. My note-book bears notes of these tests as follows, with a test in which 5 cc. of cotton-seed oil was used: "3 good froths, concentrates not cleaned"; with a test in which 10 cc. of oil was used, "3 froths, concentrates cleaned"; (166—93) with a test in which 20 cc. of oil was used, "4 froths last very small, concentrates cleaned."

The phrase "concentrates cleaned" refers to the fact that the concentrates recovered in the several successive treatments of the ore were united and returned to the test machine after the tailings had been discharged from it. To these was added enough water to make the total amount present approximately 1,700 cc., and they were reagitated substantially as before, and the floating concentrates were removed. This operation was repeated one or more times. The tailings or middlings resulting from this operation were added to the tailings produced in the first treatment of the ore. It is possible that a drop or two of acid and oil were added during this re-treatment of the concentrates, but I do not remember that this was done.

X Q. 108. Did you use the same slide machine in your cotton-seed oil test as in the oleic acid test?

185 A. The machine used was not the same machine, but was its duplicate, made from the same pattern in the same foundry.

X Q. 109. If required, will you produce one or both of these slide test machines, for the inspection of our experts and use by them, if necessary?

By Mr. Williams: Counsel for defendant having stated that one of these slide machines, used by the defendant in his tests, will be

introduced in evidence during the taking of this testimony, the question is withdrawn.

By Mr. Kremer: Counsel for complainant having submitted the statement that upon the presentation of the testimony of their expert, the slide machine used by their expert in the (167—94) tests with reference to which their said expert may testify, will be introduced in evidence, the defendant now states that before the conclusion of their expert testimony one of the slide machines, being a duplicate of the other, will be introduced in evidence, for the inspection of the Court.

X Q. 110. Referring now to your patent No. 1,022,085, I quote the following, page 1, lines 75-81:

"By following this method, I have been able to get highly satisfactory results when using as little as one-quarter of a pound of crude acid per ton of ore treated, whereas in previously used methods, several pounds have been found necessary."

Again on page 3, in giving an example of use, the specification says, lines 101-107:

186 "To this pulp while in transit to the thickeners, was added an amount of commercial sulfuric acid equivalent to from one-quarter to one-half pound per ton of ore treated. At times a decided odor of hydrogen sulfid could be noticed around the pulp-thickeners."

In your answer to X Q. 91, you mention a determination of a consumption of sulfuric acid from a quarter to a half pound per ton of ore treated, and you say that this determination was so inaccurate as to be unworthy of consideration as evidence.

Are the quoted statements in your patent founded upon these unreliable and inaccurate observations?

A. At the time the application for the patent was drawn, and, in fact, until within the last thirty to sixty days, the data referred to in my answer to X Q. 91 was considered to be reliable, within the limits of error incidental to mill-sampling. The figures given in the patent were based upon the reports referred to in my answer to X Q. 91. The amount of sulfuric acid used, while very small, (168—95) was sufficient to cause chemical action on the metalliferous minerals present, and was therefore a different amount from that specified by the patentees of the patent in suit, who particularly specified that they used an amount of acid "insufficient to cause chemical action on the metalliferous minerals present." The only evidence at hand as to the amount in pounds proportional to the tons of ore treated in the experimental plant, is that referred to in my answer to X Q. 91.

187 X Q. 111. Then, as I understand you, the statements which I have quoted from your patent are inaccurate, unworthy of consideration as evidence, and, in fact, untrue?

A. The statements referred to are undoubtedly approximately true, but cannot be said to be scientifically accurate, and were, therefore, in my answer to X Q. 91, not vouched for as acceptable as evidence, which I understand must be, in such matters, scientifically accurate.

In explanation of the testimony of Jesse C. Gibson that he had charge of the operations of the flotation plant installed at Basin, Montana, from the latter part of July, 1911, up to about February 7, 1912, it is my memory that the experimental machine was used intermittently for probably between one and two months from about the 1st of August, 1911, and that its use was altogether abandoned after it had been demonstrated that the process evolved by me at Basin could probably be successfully used, and that after the experimental machine had been abandoned, another machine was made use of in the mill. It is my memory that this second machine was thrown into service on or about the 13th or 14th of October. I have no definite record at hand and may be, mistaken as to this date. My memory is, however, that this machine was either in course of construction or completed on October 9, 1911, when the present suit was (169—96) commenced. This machine is in existence today.

The apparatus used by me at Basin, Montana, which has been referred to as the experimental machine, did not contain any
188 inclined guide plate such as is shown in the Hoover patent No. 953,746. In front of the opening through which the material agitated in the agitating cells passes into the overflow settling-box was placed a submerged trough with horizontal bottom and vertical sides; the top of the front side of this trough was submerged under three or four inches of water. The function of this submerged trough was to direct the flow of the material and prevent a rapid surface current being directed over the descharge lip. This trough is indicated in my sketch by a broken line in each instance alongside the letters V, V^1, etc., and might well be indicated by the initials C. R. B., current retarding box.

To my best recollection, I first saw a copy of the patent to Hoover referred to, No. 953,746, during the spring of 1911, when I received a number of patents relating to flotation processes from the United States Patent Office, and I first say a copy of the patent to Hoover No. 979,857 at the same time.

After the termination of my employment by Minerals Separation, Limited, or about that time, I discussed with the model maker, Dearden, who built the slide machine, the matter of obtaining a duplicate of this machine, explaining that I wished the machine for my own personal use, and obtained from him the figure which he would have to charge for it, if he was to make one for me. He asked me if I thought Minerals Separation would have any objection to his furnishing me with the machine, and I told him that I
189 did not know, but that it was possible that they would. The figure that (170—97) he asked for one was entirely prohibitive, and I dropped the matter, knowing that whenever I wanted one I could have one made for me at a cheaper price. As the machine was unpatented and was designed by myself and Mr. Hoover, I could see no impropriety in attempting to get one made, and naturally went to the man who had previously made one for me.

I have heretofore stated that I saw in operation in the London plant a special test machine devised by Mr. Nutter, and which I

understood was not successful. I have no definite memory of having seen any other large test machine working in the London plant. I am of the belief that I did not, and am strengthened in this belief by the definite memory that, before I left the employ of Minerals Separation, Limited, Mr. Howard, foreman at the test works, had promised to write out for me a complete statement with directions as to how to proceed to carry on a working test. Such statement had not been delivered to me when I decided to sever my relations with Minerals Separation, Limited, and I thereupon turned all papers belonging to the company in my possession over to the secretary, Mr. Williams, and wrote a letter to Mr. Howard telling him not to forward the statement referred to because of my intention to leave the company.

When I witnessed the operations on the San Francisco del
190 Oro mine in Wales, I observed a very scanty froth on the surface of the spitzkasten.

It is difficult to obtain the best results in the flotation process when the temperature of the pulp is much below 25° centigrade, and the necessity for operating at about 25° centigrade or above arises from the fact that, even if the oil used were brought into a fluid condition (171—98) by heat, it would solidify immediately upon being dropped into a cold pulp.

At the time of the receipt of the letter from Minerals Separation, dated November 23, 1910, I was aware of the existence of zinc sulphide ores at Butte, Montana, and of the fact that they were being worked. (172—99)

Testimony for Defendant of Eugene A. Byrnes.

WASHINGTON, D. C., May 1-14, 1912.

Direct examination:

I am fifty years of age, a resident of Washington, D. C., and by occupation a metallurgical and chemical engineer. I am a graduate of Michigan and Columbian Universities and received therefrom the degrees of Bachelor of Arts, Master of Laws, and Doctor of Philosophy. After graduating from the University of Michigan, I taught physics for a short time and then entered the examining corps of the United States Patent Office, of which I was a member for seventeen years. For ten years I was Principal Examiner of the Division of Metallurgy and Electrochemistry of the United States Patent Office, having charge also of the laboratory. I re-
191 signed from the United States Patent Office in 1901 and engaged in private practice. I am a member of various scientific bodies, including the American Chemical Society, the American Electrochemical Society, and the Society of Chemical Industry. As Principal Examiner in the United States Patent Office it was my duty to determine the novelty and patentability of inventions relating to the treatment of ores and the recovery of metals. I had to do with a great many applications involving the recovery of floating minerals and the recovery of minerals by flotation, including

the well-known Potter and Delprat methods of flotation, which involve the use of a chemically generated gas. In my practice I had much to do with the separation of minerals and their recovery by flotation, including improvements on th Potter and Delprat methods and methods involving the separation of sulfides by aeration, such as the Macquisten method, which method I assisted in (173—100) operating and demonstrating. I have visited many of the principal mining sections in the west and am familiar with the apparatus used in mining and metallurgy. I have frequently testified in patent suits relating to metallurgical subjects both for individuals, corporations, and the United States Government, and have testified concerning the recovery of zinc. I maintain a chemical laboratory at Washington, D. C., and am principally occupied in investigating the novelty of and giving opinions and testimony relative to chemical inventions and patents therefor. I am an
192 associate editor of the Journal "Metallurgical and Chemical Engineering."

I am familiar with United States patent 835,120 in suit and with the art to which it relates.

United States patent 345,951, granted to Hezekiah Bradford, July 20, 1886, utilizes the well-known fact that finely divided minerals, although having a weight or specific gravity much greater than that of water, will nevertheless float on the surface of water, provided they are dry or only slightly wetted, or if wetted, are reaerated by lifting them out of the water into the atmosphere whereby they become coated with a film of absorbed air. Such particles float on water by reason of the well-known capillary phenomenon called "surface tension," the upper surface of the water acting like a thin, elastic membrane, and being slightly depressed by each air-coated particle, not coming in actual contact with it, but depressing the surface of the water beneath it until it displaced an amount of water equal in weight to that of the particle. In this way films of dust float on water, although the dust consists of individual particles of rock much heavier than water. An illustration of this phenomenon is the (174—101) fact that a sewing needle, although having a specific weight about eight times that of water, will nevertheless float on water if the surface of the needle be coated with a slight imperceptible film of oil or grease.

United States patent No. 348,157, granted August 24, 1886, to Carrie J. Everson, contains the following information:

193 (1) That any fat or oil, including red-oil or impure oleic acid, cotton-seed oil, or petroleum and its constituents, has a selective action or preferential affinity for comminuted metals and metallic substances admixed with comminuted quartz or other rocky gangue.

(2) That a mineral or vegetable acid, or a soluble neutral or acid salt, such as sulfuric acid or a sulphate tends to effect a union of the metallic portion of the ore with the admixed fat or oil, and to enable it to be retained thereby during the separation of the gangue, the use of both the fat or oil and the mineral or vegetable acid or salt being specified as the essential feature of the method.

(3) That the material used for oiling the mineral should be sufficiently liquid to enable it to be thoroughly brought in contact with the mineral, and in winter, when it has become solidified, it should be heated to melt and thin it, although in summer temperature such heating may not be necessary; that some of the oils or fats prescribed are solid at ordinary atmospheric temperatures, for example, tallow which the patentee notes should be used melted; that the red-oil, or impure oleic acid, mentioned, ordinarily produced from tallow in separating the stearin and other harder fats used for candle-making, etc., may be (175—102) either solid or liquid, depending on the season of the year, whether winter or summer, and that other oils mentioned, cottonseed, caster, sperm, linseed, and petroleum, are liquid at ordinary atmospheric temperatures.

194 (4) That the proportions of oil or fat and acid used must vary according to the kind of each employed and according to the kind of ore to be treated, and must be determined in individual cases by the operator.

(5) That the operation of concentration as a whole, or in its practical form as applied to the separation of rocky mineral ores, involved the reduction of the quartz or other rock containing the mineral to a powder; that is, fine comminution is necessary to liberate the mineral from the gangue, or produce separate particles of each, enabling the mineral to be preferentially coated with the oily material.

(6) That thorough agitation of the mass, or pulp comprising water, the finely divided ore, the oil or fat, and the acid, is necessary, the purpose being to bring the mineral into contact with the oil and acid as completely as possible to enable each particle of mineral to be preferentially oiled; and that the particular apparatus to be used is not described or illustrated, the statement being made that, when using a naturally liquid oil, like petroleum or paraffin-oil, the mass is first thoroughly agitated and the concentrate will then be separated from the sand or gangue by flotation, "by means of a constant overflow of water from a washing-out vessel, by which overflow the concentrate will be floated off * * * because the sand is heavier than the mixture of mineral, oil, and acid." As the patentee states that devices and methods of this character are well known

195 in the wet separation of (176—103) ores, reference is evidently here made to the use of the common spitzkasten, in which a constant current of water lifts the lighter material which floats off, while the heavier portions gravitate to the bottom against the current.

The reference in United States patent 466,753, granted January 5, 1892, to Edgar A. Hockley, to flour gold and silver as light does not mean that the specific gravity of gold and silver or the other mineral to be recovered is less than that of the gangue, but means that it tends to float upon the water by reason of the surface-tension phenomenon heretofore referred to, due to the fact that the very small particles of metal or mineral are surrounded by a film which prevents them from being wasted. The patentee proposed to increase the natural floating tendency of the mineral by injected

streams of air, etc., which would tend to attach more air to the particles, as films or bubbles, enabling it to float as a scum.

United States patent 469,599, granted February 23, 1892, to Albion H. Rouse, contains the statement that the slime water is acted upon by an innumerable number of air bubbles escaping from perforate pipes into which air is forced, the constant upward circulation of air through the slime water tending to elevate all foreign matter to the surface and to form a mass of strong foam.

United States patent No. 676,697, granted June 18, 1901, to Francis E. Elmore, contains a description of a process based
196 on the selective action or preferential affinity of oil for mineral rather than gangue, the oiled metallic particles being floated up by the oil while the tailings subside.

United States patent No. 689,070, granted, December (177-104) 17, 1901, to Alexander S. Elmore, corresponds to British patent No. 6519 dated March 28, 1901. This patent refers to the selective action or preferential affinity of oil for metallic substances as distinguished from earthy or rocky constituents of ores, and to the fact that a slight amount of acid greatly enhances this selection action.

United States patent 735,071, granted August 4, 1903, to Guillaume D. Delprat The principles of this patent are set forth in lines 13 to 33 and lines 77 to 89 of the first page of the specification of this patent.

United States patent No. 736,381, granted August 18, 1903, to Moritz F. R. Glogner, sets forth the inventor's process in the passage extending from line 5 to line 36 upon the second page of the specification, and also in the passage extending from line 62 to line 68 on the first page of the specification. Graphite, to the separation of which the Glogner patent process is directed, is one of the minerals the recovery of which is contemplated by patent 835,120 in suit. The Glogner process relied on the preferential affinity of petroleum for graphite rather than rock and gangue, and directs that the mixture of water, ore and petroleum shall be given a strong agitation, as by rotating, rocking or reciprocating it thereby causing
197 every graphite particle to be coated with petroleum. Such strong agitation is well designed not only to intimately distribute the petroleum, but also to aerate the pulp and cause the oiled mineral to float to the top as a froth. The waves formed by reciprocating the agitating vessels in short shocks would naturally entrain and intermingle with the pulp a large amount of air in the form of bubbles, just as an ocean wave entangles air and forms a floating froth or foam. (178—105)

Patent No. 745,960, granted December 1, 1903, to Israel F. Good, sets forth the patentee's process in the passage extending from line 12 through line 18 on the first page of the specification, and in the passage on the second page of the specification extending from line 20 to line 24.

United States patent No. 777,273, granted December 13, 1904, to Arthur E. Cattermole, is one of the patents referred to in patent No. 835,120 in suit. Cattermole patent No. 777,273 disclaims as old, but utilizes, the selective action of oils for the metalliferous

constituents of ores. It describes but does not claim as new the use of acid to increase the selective action of oil. It notes that a small amount of acid, for example, a fraction of one per cent on the amount of water in the pulp, is sufficient and directs violent agitation of the mixture of pulp, oil and acid. Cattermole patent 777,273 illustrates as a means for performing the agitation of a series of connecting vessels each containing a revolving cone, which is
198 the precise type of agitator adopted in the patent in suit. The percentage of oil, 4 per cent to six per cent, recommended in the Cattermole patent, is based on the weight of the metalliferous minerals that are present in the ore and not on the ore itself.

United States patent No. 776,145, granted November 29, 1904, to Charles V. Potter, discloses a process similar to that of Delprat patent No. 735,071, except that the pasty mass containing the metallic concentrates which is removed by overflow or skimming is formed by the action of sulfuric acid, stirrers, which "are freely used" and heat, which might be that of steam injected into the agitating vessel at or near its bottom. The agitating vessel (179—104) illustrated in the drawing of Potter patent 776,145, consisting of a vertical shaft carrying four radial stirrer arms at its lower end and rotated by gears at the upper end, is practically identical with that used by defendant in this suit and shown by him in this recent United States patent No. 1,022,085. The free use of such an agitator causes the solution to become thoroughly aerated and impregnated with the air bubbles which would assist the gas chemically generated in forming a pasty floating mass carrying the concentrates. Potter indicates that the effect of the applied heat is to increase the generation of gas by the action of the acid on the ore.

I will now refer to United States Patent No. 777,274, granted December 13, 1904, and United States patent 788,247, granted April 25, 1905, to Arthur E. Cattermole, Henry L. Sulman
199 and Hugh F. Kirkpatrick-Pickard. The first of these patents is referred to in the patent in suit, as describing the optional method of liberating the oleic acid used for oiling the mineral "in situ" in the pulp by decomposing a dilute soap solution with mineral acid. The applications for these two patents were filed simultaneously. They contained identical descriptions of the method of oiling the mineral by a fatty acid generated in situ. The first patent, No. 777,274, describes separation of the oiled mineral from the gangue by the process set forth in Cattermole patent 777,273, that is, by causing the coated metalliferous particles to adhere together and form granules or small agglomerated masses which sink. In the passage beginning at line 53 of the first page of the specification of patent 788,247, a method of separation is described which consists in floating oil-coated metalliferous mineral particles by generating gaseous bubbles in the mixture which preferentially (180—105) attach themselves to the fat coated particles, and the patent stated that if the ore contains a carbonate, any small excess of acid used to decompose the soap solution will liberate bubbles of carbonic acid gas, which would float the mineral particles to the surface, or that a suitable carbonate

might be added to the ore for the purpose of generating carbonic acid gas.

United States patent 793,808, granted July 4, 1905, to Henry L. Sulman and Hugh F. Kirkpatrick-Pickard on an application
200 filed October 5, 1903, contains an explanation of the patentees' process in the passage beginning at line 9 of the first page of the specification of the patent and extending through line 11 of the second page of the specification.

The apparatus shown in Fig. 1 of the drawing of patent 793,808, is well adapted to preferentially coat the metalliferous constituents of the ore with a minute film of oil insufficient in itself to raise the mineral, and also to attach to the oiled mineral particles, films or bubbles of air to float them as a froth. The coiled perforated pipe would also act as an efficient agitator to entangle and intermingle a considerable amount of atmospheric air with the pulp, assisting the aeration. Patent No. 793,808 provides for varying the temperature of the pulp to produce the best results and the patentees refer to the known methods of chemically generating a gas to float the oiled particles.

Both patents 793,808 and 788,247 disclose the following facts:

(1) The preferential affinity of oils, fats and the like for mineral particles rather than gangue.

(2) The preferential affinity of the oiled mineral (181—106) particles for films or bubbles of gas, however supplied to the pulp.

(3) The flotation and removal of the oiled and aerated metalliferous particles as a froth.

(4) The addition of acid to a pulp of ore containing carbonates or sulfids capable of reacting with the acid.

201 United States patents 807,501 and 807,503, granted December 19, 1905, to Alfred Schwarz, the first upon an application filed April 19, 1905, and the second upon an application filed May 27, 1904, disclose the following points:

(1) The selective action of oil generally, mineral, vegetable or animal, for the metalliferous constituents of ore, especially sulfid ores.

(2) The use of oiling the mineral of an oil containing a fatty matter which is solid at normal temperatures such as stearin; and of a mixture of an oil, which may be animal oil, and a fatty matter, which may be stearin, which is solid at normal temperatures. "Red oil," the commercial form of impure oleic acid produced by the candle and soap maker, is a mixture of this character, containing stearic and palmitic compounds, and being entirely solid at the lower range of atmospheric temperatures.

(3) The use of a sufficient quantity of the oil or oily mixture to effect the desired separation, that is, the oiling and floating of the metalliferous constituents.

(4) The use of slightly acidulated water to prevent the adhesion of the oil or oily mixture to the gangue or tailings, that is, to increase its selective action or preferential affinity for the mineral.

(5) The thorough mechanical agitation of the ore with the oily material and with the acidulated water, as by (182—107) agi-

tating blades, in open vessels, which agitation will not only thoroughly distribute the oil throughout the ore and cause it to
202 coat the mineral particles, but will also entangle the atmospheric air and thoroughly aerate the mixture to produce a floating froth of concentrates.

(6) Further aeration of the mixture by the injection of streams of air, steam or carbon dioxide gas, giving the froth sponginess and increased floating power, thus floating some of the oiled mineral which might otherwise remain in the tailings and necessitate their re-aeration in a subsequent operation.

(7) The heating of the mass, as by steam-jacketing the agitator vessel, or using heated or boiling water, to maintain the oiling agent in a liquid condition

(8) The flotation of the aerated and spongy mass of the selective material, or oiling agent, with the entrapped metallic constituents of the ore, and its delivery to a centrifugal filter, the tailings being settled out and withdrawn at the bottom.

(9) The retreatment of the tailings, if necessary, for the recovery of any values therein contained.

United States patent No. 809,959, granted January 16, 1906, to Edmund B. Kirby on an application filed December 14, 1903, and United States patent 838,626, granted December 18, 1906, to Edmund B. Kirby on an application filed December 17, 1903, contain sufficient description of the patentee's process and the apparatus used therefor.

The two Kirby patents show the following points:

(1) The selective action or preferential adhesion of oils generally, and especially kerosene or a solution of bitumen in kerosene,
203 for the metalliferous constituents of ore, kerosene being specified as useful with sulfid ores. (183—108)

(2) The use of "a sufficient amount" of the oil or oil solution to attain "excellent results" in the separation of the mineral by flotation.

(3) Varying the temperature at which the solution is used to regulate the preferential affinity.

(4) Adding acid to regulate the preferential affinity.

(5) The thorough mechanical agitation of the ore-pulp, acidulated, and the oil, by a rapidly rotating shaft having radical agitating blades, which type of agitator, employed by the defendant in this suit, is found to be a most efficient one for intermingling atmospheric air with the mass and thoroughly aerating the oil mineral to produce a floating froth of concentrates.

(6) Further aeration of the mixture by the injection of streams of air or gas, such as carbon dioxid, hydrogen, or marsh-gas, acting to float the less buoyant, larger and heavier mineral particles trapped in the tailings, the separation of the froth of concentrates from the tailings by floating the scum over a series of vessels of the spitzkasten type, of progressively increasing size with an upcurrent of water, and the delivery of the concentrates to a filter.

(From the British patent, No. 12,778, granted June 4, 1902, to

Alcide Froment, corresponding to his Italian patent No. 63,723, the witness quoted from line 21, page 2, through line 14, page 3.)

204 The Froment patent discloses the following points:

(1) The preferential affinity of a fatty substance," such as "ordinary oil," for metalliferous particles, specifically natural sulfids reduced to powder.

(2) The use of a relatively small amount of oil, for example, a "thin layer" in the test tube experiment treating (184—109) 41 grams of pulp, the purpose being merely to "moisten" the sulfids.

(3) The addition of a small amount of sulfuric acid to the pulp.

(4) The agitation of the entire mixture for a brief space.

(5) The liberation of a gas in the mass and the attachment of bubbles of the gas to the oiled sulfide particles.

(6) The consequent flotation of the sulfid, rising to the top of the liquid as a distinct magma or froth.

(7) The removal of the concentrate froth and the separation of the oil therefrom for re-use.

In the test tube experiment, limestone, that is, calcium carbonate, is added to the ore, reacting with the sulphuric acid added to the water to produce carbon diodide, or carbonic acid gas, this gas being evolved in a nascent state and its bubbles becoming attached to the oiled sulp-ide particles or each becoming covered with an envelope of the fine sulphide particles. The patentee notes that the amount and character of the limestone used in the process should be such that the evolution of gas is not too rapid so as to project the contents of the tube out of its top.

205 In "Example 1" of the Froment patent, the specified ore naturally contains carbonates, to wit, carbonate of iron, dolomite (a double carbonate), and calcite (calcium carbonate) which are chemically like limestone. These carbonates would also react with the acid to evolve gas and float the oiled sulfid. The apparatus used for agitating the mixture of ore, oil, water and acid in this "Example 1," or in a practical operation, is not described, (185—110) evidently because Froment considered that suitable agitators were well-known and would be chosen by those skilled in the art. Thorough agitation is obviously necessary to distribute the small amount of oil thinly over the innumerable small particles of sulfid to be coated.

Some simple experiments which I have made in connection with this Froment patent may be of interest, as follows:

(1) A glass test tube holding 100 cubic centimeters was held filled with water, corked and well agitated for a brief period. The air in the tube above the water was thus shaken into it and intimately distributed throughout it in the form of fine bubbles, which, however, quickly rose to the surface of the water and escaped as soon as the agitation was discontinued.

(2) The same experiment was repeated, with the difference that one drop of "red oil," the impure oleic acid used by defendant in carrying out his process, was first added to the water. In this case,

the fine bubbles of air entangled in the water upon agita-
206 tion did not quickly float, but remained distributed throughout the water for a considerable period, giving it a milky appearance.

(3) Ten grams of the ore which is being treated by defendant according to his process involved in this suit, finely powdered, was taken and placed in the empty 100 cc. test tube. This ore, from the "Black Rock" mine of the Butte & Superior Copper Company, assayed about 20 per cent zinc, equivalent to a content of about 30 per cent of zinc sulfid. It also contained rhodochrosite, a manganese carbonate easily decomposed by sulfuric acid to give carbon dioxide gas. Upon adding thirty cubic centimeters of water to the ore in the test tube, some of the mineral floated by (186—111) reason of the air within the mass of ore and the films of air surrounding some of the small particles.

(4) A few drops of sulphuric acid were now added to the ore and water in the test tube, and the mixture was gently heated, whereupon gas was chemically liberated by the action of the acid on the carbonate and sulfid of the ore, evolving carbon dioxide and hydrogen sulfid, and considerable mineral rose to the surface of the liquid, floated by the adherent gas-bubbles, as in the well-known Potter and Delprat methods, heretofore referred to by me. This mineral, however, floated for a brief period only and then again subsided to the bottom of the tube.

(5) One drop of olive oil was now added to the acidulated water and ore in the test tube, and the tube was agitated for a brief
207 space, whereupon a large mass of oiled and aerated mineral floated to the top, in the form of a magma or froth having the characteristics described in the Froment patent. It was found that agitation of the mixture for a brief period, such as was necessary to distribute the drop of oil over the innumerable particles of zinc sulfid in the ten grams of ore and moisten their surface with a film of oil, also thoroughly aerated the liquid, by the air shaken into it, just as in the experiment numbered (2) above. These fine bubbles of air throughout the mass, as well as the nascent gas chemically liberated throughout the mass, attached themselves to the oiled particles and assisted in floating them to the top as a froth.

(6) In order to oil the mineral particles without agitation, two drops of cotton-seed oil were dissolved in a few cubic centimeters of ether, and ten grams of the finely powdered "Black Rock" ore heretofore described was moistened with the solution. The ether was allowed to (187—112) evaporate, leaving the oil adhering to the mineral particles as a thin film. The oiled ore was then placed in a test tube, thirty grams of water were introduced, five drops of sulfuric acid were added, and the whole was gently heated to cause the sulfuric acid to react on the carbonate in the ore. The nascent gas generated by the reaction attached itself to the oiled mineral particles and floated them to the top.

(7) Ten grams of the "Black Rock" ore were mixed, in one in-

stance with one gram of limestone, or calcium carbonate, as
208 prescribed by Froment, and in another instance with a half gram of rhodochrosite, the manganese carbonate occurring in the "Black Rock" ore, a thin layer or a few drops of olive oil were added, and a few drops of sulfuric acid. On warming to start the reaction, and agitating for a brief period, the oiled mineral floated as a froth.

An agitating apparatus consisting of an open vessel in which is centrally journaled a vertical shaft having radial arms at its lower end, the shaft being rapidly revolved, was shown and described in Schwarz patent 807,503 and the Kirby patents 809,959 and 838,636, and such agitators constitute an efficient means for aerating ore pulp or entangling atmospheric air and distributing it throughout the mass in innumerable fine bubbles capable of attaching themselves to oiled mineral particles and floating them as froth. I have had considerable experience with apparatus of this type, both with a form of laboratory or test apparatus designed in part by defendant, and called a slide machine, and with the apparatus commercially employed by the defendant and installed in the mill of the Butte & Superior Copper Company at Basin, Montana. In both the laboratory and commercial apparatus the agitator is an (188—113) open vessel in which is journaled a vertical shaft driven by a belt or gear at one end and having at its other end four radial arms or blades. I also have had built and had tested the agitator shown in the patent in suit, consisting of an open vessel in
209 which is journaled a shaft carrying a hollow cone; and I also had constructed the agitator shown in Figure 1 of the Sulman & Kirkpatrick-Picard patent No. 793,808 consisting of an open trough near the bottom of which is journaled a perforated coiled pipe. Both the cone and the coiled pipe stir the water or ore pulp vigorously and produce a froth, but appear not to be as efficient as the radial arm type.

By using the Hyde slide machine, I have been able to carry out a process of separation corresponding to that of the Kirby patent 809,959. For this purpose I took 500 grams of the finely pulverized "Black Rock" ore which is treated by defendant, and mixed it with from "three to five times" its weight of water, that is, with sixteen hundred cubic centimeters, acidulated by the addition of 1 cubic centimeter of sulfuric acid, and with an amount of kerosene equal to one-fourth that of the ore, that is, 125 grams. The temperature of the water used was 35° C. On agitating this mixture for thirty seconds by rotation of the central shaft having four radial arms, I was able to so thoroughly oil the sulfid and aerate the oiled particles by the air entrained by the agitation, without any injection of streams of air to float the particles entangled in the tailings, as to produce a floating froth of concentrates nearly half an inch thick. I also roughly imitated the operation of blowing in air carried out by Kirby, by the use of a single tube pushed downward into the tailings at the bottom and moved about therein. By

removing this first (189—114) froth and repeating the
210 operation of aerating by agitating, I was able to remove so much of the zinc sulfid from the ore as to leave the tailings comparatively light in color, that is, consisting largely of gangue.

By the use of the same Hyde slide machine, I have also carried out the process of the Schwarz patents 807,501 and 807,503, thoroughly mixing the ore with oil before agitating and aerating the mass to produce the froth of concentrates. For this purpose, I took 500 grams of the pulverized "Black Rock" ore, assaying 20.3 zinc, added 20 cc. of cotton-seed oil and mixed the whole thoroughly with a blade, giving a homogeneous mass having the consistency of molding sand. The slide apparatus was then filled to the normal level with 1,700 cc. of water acidulated with 1 cc. of sulfuric acid, its temperature being 76° F. The oiled ore was added and the mixture was then agitated for thirty seconds by driving the vertical shaft with radial agitating blades. A heavy froth was produced and removed. The mass was then reagitated for the same period, another froth made and removed, and this operation repeated until six froths had been separated. These froths, combined, were filtered and dried, and their weight was found to be 230 grams. The assayer reported their contents of zinc as 41.7 per cent. The assayer to whom I refer was W. R. Hocking, manager of "The Rombauer Assay Co., of Butte, Montana. The tailings from these operations were also removed and dried, and their weight was found to be 277 grams, containing, as reported by the assayer, 0.7
211 per cent of zinc. These tailings were nearly white and it was evident to the eye that the metalliferous constituents thereof had been almost entirely removed. In this experiment, I did not inject a gaseous fluid, such as air, steam, or carbon dioxid, which (190—115) Schwarz states may optionally be used, relying simply on the agitation to effect the production of a froth. The specific gravity of cotton-seed oil being about 0.9, the 20 cc. which I used in this test was about 18 grams, or 3.6 per cent of the ore treated. The zinc being present in the ore in the form of its sulfid, a content of 20 per cent of zinc, as reported, corresponds to a content of its sulfid of about 30 per cent. The 500 grams of ore therefore contained about 150 grams of the zinc sulfid, and the 18 grams of cotton-seed oil were thus 12 per cent of this metalliferous constituent of the ore.

I also carried out the operation of the Everson patent 348,157, by using the Hyde slide machine to effect the thorough agitation of the oiled ore and removal of the sand by means of acidulated water, floating off the concentrates. This Everson process is similar to that of Schwarz, in that the ore is oiled before it is agitated with acidulated water. For this purpose, I employed the materials and proportions specified in lines 75-92 of the patent, using as an acid the sulfuric acid mentioned in lines 8 and 119. I used eight times the amount specified, that is, 16 ounces of the pulverized "Black Rock" ore, and 24 fluid drams of petroleum, in this instance having
212 a gravity of 33° Beaume. I thoroughly mixed the ore and petroleum, producing a homogeneous mass having the con-

sistency of damp sand. I then placed in the slide machine 1600 cc. of water, acidulated with 3 cc. of sulfuric acid, having a temperature of 27° C. The agitator of the machine was then started and the oiled ore gradually added. The agitation was continued for thirty seconds, producing a good froth, which was removed. The mixture was then reagitated for thirty seconds, and the second froth removed. In order to maintain the acidity of the (191—116) water, to assist in cutting away the sand from the oiled material, as described by Everson, 1 cc. of sulfuric acide was now added. The mixture was then reagitated several times and four froths removed. 1 cc. of sulfuric acid was again added and the mixture was successively reagitated three more times and three froths removed. The nine froths were mixed and filtered. The residual concentrates were then washed several times with gasoline to entirely remove the oil therein, and were dried and weighed. Their weight was 144 grams. The tailings were nearly white or quite light-colored, the greater amount of the zinc sulfid having been removed therefrom, as was apparent to the eye.

My tests of the apparatus which I had built in accordance with Fig. 1 of the Sulman & Kirkpatrick-Picard patent 793,808 show that it is capable of producing a very satisfactory froth of concentrates.

213 This apparatus, which I had built to scale from the drawing of the patent, had an agitator of perforated coiled gas-pipe, three-eighths of an inch in internal diameter, and about four feet long. This coil, when rapidly rotated by power, produced a very vigorous agitation and stirring of the liquid in the tank or trough. I tested it without supplying compressed air to the end of the pipe, and found that while it would stir in some air from the surface of the liquid, it was not an efficient means for entangling atmospheric air, as is the Schwarz, Kirby and Hyde agitator with radial arms. When the apparatus was run on an ore-pulp consisting of warm water and pulverized "Black Rock" ore, and compressed air carrying "red oil" was supplied to the end of the coiled pipe, the air escaping from the perforations of the pipe was thoroughly beaten through the pulp, coating the metalliferous particles with a thin film of oil and attaching bubbles (192—117) of air to the oiled particles, which were thus raised to the surface by gaseous flotation, producing a thick and satisfactory froth. I skimmed off many handfuls of this thick froth and found it very heavy by reason of its high content of zinc sulfid. It was quite clear that several repetitions of the agitation and defrothing, or continued agitation and removal of the froth, would have separated a very considerable amount of the zinc sulfid from the ore, quite possibly rendering the apparatus a commercial one.

214 I have repeatedly operated the process of the Froment British patent 12,778 of 1902, using the Hyde slide apparatus to effect the brief agitation and frothing, and using different kinds of oil and widely differing amounts of oil. The data of some of these Froment operations, using the finely pulverized "Black Rock" ore having a zinc content of 20.3 per cent., are as follows:

A mixture of 492 grams of ore, 1700 cc. of grams of water, at 70°

Fahrenheit, 0.3 cc. of cottonseed oil and 1 cc. of sulphuric acid was agitated and defrothed five times. The five froths were filtered and dried, giving concentrates having a weight of 170.5 grams, reported by the assayer to contain 50.0 per cent of zinc. The tailings weighed 315.5 grams and had a reported zinc content of 4.2.

The process was repeated under precisely the same conditions, except that 20 cc. of cottonseed oil, or 66 times as much, was used. Six froths were made and removed, and dried concentrates, plus some oil therein, weighed 211 grams and had a zinc content of 48.3 per cent. The tailings, plus some oil therein, weighed 292 grams and contained 1.0 per cent of zinc.

The process was repeated under precisely the same (193—118) conditions, except that 20 cc. of Ehrmann's California olive oil was used. Five froths were made and removed; the concentrates, plus some oil, weighed 219 grams and having a zinc content of 44.3 per cent. The tailings, including some oil, weighed 274 grams and contained 0.6 per cent of zinc.

The process was repeated under the same conditions, but
215 using 20 cc. of "red oil," impure oleic acid, from Charles T. Perry & Co., of Helena, Montana. Three froths were made, removed and dried. The weight of the concentrates was 65 grams and their reported zinc content was 42.2 per cent. The tailings were not cleaned, but showed on their surface small particles of aggregated mineral, or "flocks," perhaps half a millimeter, or one-fiftieth of an inch, average diameter.

The amount of cottonseed, olive and "red oil" used in the last three operations was more than 3.6 per cent of the weight of the ore, and more than 12 per cent of the weight of the zinc sulphide in the ore.

The process was repeated under the same conditions, using 500 grams of ore, except that 10 cc. of "red oil" was used. Four froths were made, removed and dried. The concentrates therein weighed 202 grams, and had a reported zinc content of 47.5 per cent. The tailings were very white, weighed 288 grams, and contained a reported zinc content of 1.1 per cent. It should be noted that the "red oil" used in this test was a special or somewhat purer form of oleic acid than that used in the preceding run, more of the solid fatty acids, stearic and palmitic, having been removed by the maker, Charles T. Perry & Co., rendering it thinner and less viscous, pasty or solid at ordinary temperatures. (194—119)

I have made some tests of the apparatus shown in Figure 1 of the patent in suit, the agitator or mixing vessel and the froth-separating apparatus being made for me to scale as closely as could be de-
termined, the cylindrical vessel containing the agitating cone
216 having a height of 12 inches and a width of 6 inches.

In one run, this vessel was filled with water to the maximum height permissible with rapid rotation of the cone without throwing the water out of the vessel, which was found to be two-thirds of its height, or 8 inches. The amount of water then contained was 3,200 cc. To this water was added 1 cc. of sulphuric acid and ¾ cc. of "red oil." The water was previously heated and had a temperature of 35° C. The cone mixer was now rapidly rotated and

500 grams of pulverized "Black Rock" ore was introduced, the agitation being continued for ten minutes. The stopcock in the pipe leading from the vessel to the froth-separator was then opened, and most of the mixture siphoned out. The cone being maintained in motion, wash-water was added to remove the residue, and the vessel was slightly tilted to empty out the portion contained in the concave bottom. Some froth floated down the shallow trough and over the body of the water contained in the spitzkasten, passing on into the launder and being collected and filtered. Considerable mineral, in the form of fine individual oiled particles, also floated down on the surface of the water, as a mere film supported by surface tension. This was also delivered to the launder and collected with the froth, care being taken to recover all of the floating mineral, whether froth or film. I was not able to verify the statement in line 92 of page 1 of the patent in suit, that the scum or (195—120) mineral floated derives its power of flotation "mainly from the inclusion of
217 air-bubbles introduced into the mass by the agitation," by reason of the film flotation of so much of the mineral distinct from the aerated froth. All of the concentrates floated and collected were dried and their total weight was 33 grams. The tailings showed hardly any perceptible change in color from the original ore, as was to be expected from the comparatively small amount of mineral removed by flotation.

I then carefully washed out all of the apparatus and made another run, with 3200 cc. of water at 35° C., 1.4 cc. of "red oil," 2 cc. of sulphuric acid and 500 grams of pulverized "Black Rock" ore. The agitation was here continued for five minutes, all of the mixture in the vessel was washed out, with agitation, and all of the mineral floating as froths or films was collected and dried. The weight of the concentrates recovered was 49 grams. The tailings were very little changed in color.

From my study of the prior art and from my tests of the processes disclosed therein as well as of the process in suit, I am entirely unable to find any point of novelty in the process described and claimed in the patent in suit so far as it is carried out by the use of the apparatus shown in Figure 1. I disregard the modified apparatus of Figure 2 of the drawing of the patent in suit and the supplemental or modified processes involving solution of air in the pulp by superatmospheric pressure, or distribution of the tailings in a thin layer on a shaking table or the like, as described in
218 page 2, line 103, to page 3, line 34, and on page 2, lines 25 to 29, inasmuch as these modifications constitute the subject matter of separate patents. (196-121)

I find a clear disclosure of the preferential affinity of oils and fats for the metalliferous constituents of ores, especially sulfids, or graphite, in the specified prior patents to Everson, 348-157; Elmore 676,679 and 689,070; Glogner, 736,381; Good, 745,960; Cattermole, 777,273; Cattermole, Sulman and Kirkpatrick-Picard, Nos. 777,273 and 788,247; Sulman and Kirkpatrick-Picard, No. 793,808; Schwarz, 807,501 and 807,503; Kirby, 809,959 and 838,626; and Froment British, 12,778 of 1892.

I find a clear disclosure of the use of acid, for example, sulfuric acid, including small amounts of acid, in processes of oiling the metalliferous constituents of ore, with statements that acid increases the preferential affinity of oil for the metalliferous constituent, in the specified patents to Everson; Elmore No. 689,070, which claims this feature, i. e., the enhancement of the selective action of oil by the use of very small quantities of acid, instancing sulfuric and oleic acids, added to the ore-pulp or oil, the quantity being varied, however, to produce the best results; Cattermole, No. 777,273, acknowledged in the patent in suit, specifying a fraction of one per cent and mentioning sulfuric acid; Cattermole, Sulman & Kirkpatrick-Picard, No. 777,274, also acknowledged in the patent in suit, and No. 788,247, the description of which is identical as to the mode of oiling, and which states that any slight excess of acid beyond
219 that acting to decompose the soap solution used as a source of the oiling agent will react on carbonates or easily decomposable sulfids in the ore to generate gas; Sulman & Kirkpatrick-Picard, No. 793,808; Schwarz, 807,503; Kirby, 809,959, which particularly notes that the preferential action may be regulated by the addition of acid; and Froment, 12,778 of 1902. (197-122)

The flotation of oiled mineral particles by the attachment thereto of films or bubbles of air, or gas, or otherwise stated, by the adhesion of the oiled particles to bubbles of air or gas, is clearly disclosed in the Cattermole, Sulman and Kirkpatrick-Picard patent 788,247; in Sulman & Kirkpatrick-Picard, 793,808, Schwarz, 807,501 and 807,503; Kirby, 809,959 and 838,626; and Froment, 12,778 of 1902.

The use of agitators which, as shown by my tests, will aerate a mixture of oil and acidulated ore-pulp by entangling atmospheric air and beating it through the mixture in the form of fine bubbles, attaching themselves to the oiled mineral particles, is described in Everson; Cattermole, 777,273; Cattermole, Sulman and Kirkpatrick-Picard, 777,274; Schwarz 807,501 and 807,503, the latter illustrating and describing defendant's agitating device, a vertical shaft with agitating blades; and Kirby, 809,959 and 838,626, also illustrating defendant's stirrer with radial blades. Glogner, 736,381, illustrates an oscillating agitating vessel, in which the mixture of ore-pulp and water is thrown violently against one end of the vessel, the waves falling back through the air, thus imitating the
220 aeration and frothing produced by an ocean wave.

Froment confines his description to the process and its principles, leaving the type of agitator to be determined by the user. In Froment's test tube experiment, agitation sufficient to coat the mineral particles with a thin film of the oiling agent also thoroughly aerates the mixture, the fine bubbles of air distributed throughout it and attaching themselves to the oiled particles, acting with the chemically-evolved gas to float them. The function of the gas bubbles is identical, whether they be of atmospheric air shaken or beaten into the mixture, air or gas injected (198-123) in streams, gas chemically evolved throughout the mixture, gas electrolytically evolved by decomposition of the liquid; gas liberated by first increasing the amount in solution in the liquid by the use of pressure and

then releasing the pressure; all described in the patents referred to by me; air or gas normally in solution in the liquid and evolved by creating a partial vacuum over its surface; or gas produced by boiling the liquid, as described in patent No. 835,143, to Henry L. Sulman. The patent to Sulman, Kirkpatrick-Picard and Ballot, No. 835,479, refers to the fact that several methods are known for producing the gaseous films or bubbles used to float the particles.

The fact that oils and fatty acids in general have a preferential affinity for metalliferous matter and graphite is recognized by the patent in suit. The particular oiling agent described, oleic
221 acid, and its liberation in situ in the pulp by the decomposition of a soap solution, are disclaimed in the patent in suit as described in the Cattermole patent No. 777,274.

The fact that widely different amounts of the same oiling agent, indiscriminately over as well as under one per cent or a fraction of one per cent of the weight of the ore, may be successfully used to oil the mineral and float it by attached gas films or bubbles, is shown by the prior patents referred to by me and by the practical tests which I have made and described. It is also to be noted that the limitation of some of the claims of the patent in suit to a proportion of the oiling agent amounting to a fraction of one per cent on the ore, does not exclude the proportions specified in the Cattermole patent No. 777,273, in which the percentage of oil is based on the weight of the metalliferous mineral in the ore, and the usual range (199-124) is stated to be from 4 to 6 per cent of oil by this weight of mineral.

The use of warm water, or a warm mixture, having a temperature of say 30° to 40° C., as described in the patent in suit, is an obvious and necessary expedient when oleic acid is the oiling agent, since this acid is solid at all lower atmospheric temperatures, and must be heated to a temperature at which it is thinly liquid, to enable it to be distributed throughout the ore as a minute film covering the metalliferous particles. Oleic acid is one of the constituents of and is ordinarily derived from animal fats, such as tallow. Its behavior may be understood by referring to the analogy of butter.
222 Iced butter is solid, nonplastic and difficult to spread. At lower and moderate atmospheric temperatures, it is plastic and may readily be spread. If we wish to distribute butter as a thin film over the surface of small grains, for example popcorn, we slightly raise its temperature until it is thinly liquid.

I have made some rough tests of the impure oleic acid used by defendant in his flotation plant at the Basin, Montana, mill of the Butte & Superior Copper Company, and which was also used by me in all of my tests, except the one in which, with the slide machine, I used ten cubic centimeters of a special thin oleic acid, as stated. For this purpose, I unscrewed the plug in the side of one of the iron drums in which this oil is received at Basin. This drum had been lying in the sun outside the mill for some time. I found that the "red oil" in the drum was entirely solid, and on pushing a thermometer down into it 12 inches found that its temperature at the center of the drum was 7° C. With a stick I took out some of the solid oil,

about 400 cc., placed it in a beaker and warmed it on an electric (200-125) hot-plate in the laboratory. When a small portion of the oil had become liquefied, I removed the beaker from the plate and let it stand for a few minutes. The temperature of the liquid portion was then 18° C. I then returned it to the hot-plate and continued the heating until all the grains of solid fat suspended in the liquid had become melted. The temperature of complete fluidity, with thorough stirring, after removal from the hot-plate,
223 was about 38° C. As the temperature of the ore-pulp supplied to the Hyde flotation apparatus at the Basin plant was normally very low, far below the solidification point of "red oil," it was, of course, necessary to warm the pulp in the agitator in order to keep the oil liquid and enable it to coat the zinc sulfid particles. The flume supplying this mill with water, on different days when I examined it, was coated with ice, although the weather in April was bright and sunny. The temperature of the water in this flume, as tested by me at different times, was only 1 or 2 degrees above freezing. The temperature of the ore-pulp delivered at the bottom of the mill to the elevator carrying it to the Hyde flotation plant was found by me to be 3° C. I took a quart of this pulp in a thin vessel, carried it up to the flotation plant and allowed some of the oil feeding to the first agitator to drop upon its surface, whereon it solidified at once.

The heating of the oil, or mixture of pulp and oil, or its maintenance at a proper temperature to keep the oil liquid and effect the oiling of the metalliferous particles with a thin film, is described in the specified Everson patent; in Sulman & Kirkpatrick-Picard 793,808, in Schwarz 807,501 and 807,593; and in Kirby 809,959. (201-126)

The patent in suit is very vague as to the details of the process and as to the proportions of oil and acid to be employed, indicating that preliminary tests are necessary with different ores to determine the proper amount. Although an "example" of the application
224 of the process to a particular ore is described, the proportion of oleic acid to be added to effect the oiling is specified as "say from 0.02 per cent to 0.5 per cent on the weight of the ore," leaving it to the user to determine whether he should use the smaller proportion, the larger one, twenty-five times as much, or some intermediate one. Later, the description states, in the most general terms, that the proportion may be "under 0.1 per cent of the ore." So, again, the amount of sulfuric or other acid or salt to be added may be any fraction of 1 per cent or up to 1 per cent.

The particular "different oily substances" which are suitable "with different ores" are not described, nor any characteristics which would enable the user to determine the proper one. The agitator or mixing vessel shown is confessedly old with Cattermole, and is relatively inefficient. The spitzkasten froth-separating apparatus is a very old device, and is shown in the prior art cited by me. It is, therefore, my opinion that this patent in suit describes and claims no new process, and employs no new principles or apparatus, except

for the subject matter expressly disclaimed as that of other applications then pending but since patented.

At this point the witness completed his answer wherein he has described the patent in suit and prior patents and experiments and tests, and complainants' counsel gave notice of motion to strike out as irrelevant all descriptions of (202-127) tests alleged to be
225 of the processes of prior patents not carried out with the procedure or in apparatus such as are disclosed in such patents. Complainants' counsel also noted that the experiments above described by the witness, not having been made in the presence of opposing parties, the observations and conclusions of the witness were objected to as not the best evidence, unless an opportunity were afforded to complainants to repeat those experiments, and the apparatus used in those experiments were offered in evidence.

Complainants' counsel also gave notice of motion to strike out as incompetent all parts of the answer referring to patents not pleaded by the defendant, with consent, however, to the defendant to amend his answer to include such patents therein, subject to the usual condition that should he prevail upon any of these patents, he may not recover costs for any procedure prior to the deposition of the present witness.

Complainants' counsel also noted that of the patents referred to by the witness, the following were issued subsequently to the application for the patent in suit and were, therefore, not prior patents: Sulman & Picard, 793,808; Schwarz, 807,501; Schwarz, 807,503; Kirby, 809,959; Sulman, Picard & Ballot, 835,143; Sulman, Picard & Ballot, 835,479; Kirby, 838,626.

It is common practice in the art of treating minerals by the cyanide process to thoroughly aerate the ore pulp, by a variety of methods, for example by injecting streams (203—128) of air; by flowing the pulp over an aerating surface, in a thin sheet,
226 in contact with atmospheric air, or by heating air into the pulp by an agitator. An agitating apparatus for this purpose employing an open tank, in which is journaled a vertical shaft carrying four radial blades at its lower end is shown, for example, in U. S. patent 729,805, granted June 2, 1903, to John and Lee Staveken, in Figs. 2 and 3.

The following passages in the Stoveken patent describe the aeration referred to: Page 1, lines 88-94; page 2, lines 40-50; page 2, line 114 to page 3, line 8.

The stationary wings *j* described in the Stoveken patent are an important feature to produce thorough aeration by agitation in a cylindrical open vessel, since they prevent the rotation of the pulp as a mass, substantially at the same speed as the radial arms. The same result is produced in the apparatus used by the defendant by the use of a square tank. The agitator of the patent in suit is defective as an aerating machine, as I noted in operating it, by reason of the specified rotation of the entire body of pulp within the smooth cylindrical vessel.

Complainants' counsel here gave notice of motion to strike out the above as incompetent for the reason that the patent referred to

had not been pleaded, subject to the consent stated in the preceding like objection.

In the specific "example" of the application of the process given on page 1, lines 70-101 of the patent in suit, the statement as to agitation is as follows:

" * * * The mixture is warmed, say, to 30° to 40° Centigrade and is briskly agitated in a cone mixer or the like, as
227 in the processes previously cited, for about two and one-half to ten minutes, until the oleic acid has been brought into efficient contact with all the mineral particles in the pulp." (204-129)

All processes dependent on the oiling of the mineral particles in the pulp require that the oil be brought into efficient contact with these particles. While this result can be effected without agitation, by dissolving the oil in ether and saturating the dry ore with the solution, in practice, and in the various oil-gas flotation processes set forth in the prior art referred to by me, the oiling is effected by mechanical agitation, which would obviously be continued until the mineral particles had been brought into contact with the oil and coated therewith.

With reference to the statement occurring in the patent in suit, lines 48-51 on page 1 of the specification, I see no advantage to be derived from the use of such small proportion of acid except a saving in cost, assuming, without intending to admit, that an acid capable of reacting on the metalliferous minerals would not so react if used in small proportion. Acid capable of reacting on constituents of the ore to produce a gas has the double function of increasing the preferential affinity of the oil for the mineral, which requires an amount not definitely specified in the patent in suit, and which doubtless varies with different ores; and of assisting in the flotation by the production of bubbles of gas, evolved in a nascent state, and
228 in minute and extended subdivision throughout the body of pulp, wherever the acid comes in contact with a gas-generating particle of ore.

I find nothing in the patent in suit that would guide one as to the amount of oil and acid to be used further than or more definite than the directions set forth in the Froment British patent, 12,778. The patent in suit states that a preliminary test is necessary with any particular ore to determine the oily substance to be used, and (205-130) in the specific "example" simply specifies "a very small proportion of oleic acid (say, from 0.02 per cent to 0.5 per cent on the weight of ore), a very wide range, with no statement or indication as to whether the 0.02 per cent is preferable or the higher limit, twenty-five times as much, or what conditions are to determine the amount to be used. In the Froment patent 12,778 of 1902, it is stated that the sulfids reduced to powder are to be "moistened" by the fatty substance, indicating that a sufficient amount should be used to coat the surface of the particles with a film. In the test tube example, for a charge consisting of 41 grams, a "thin layer" of oil is specified.

The apparatus illustrated in Fig. 1 of the drawing of Sulman and

Picard patent 793,808 would not be operative to accomplish the desired result without vigorous rotation of the finally coiled perforated pipe B^1. I have tested this apparatus without rotation of the coiled pipe and found that the air simply streamed upward and that
229 the oil rose to the surface without causing the formation of any froth.

Carbonic acid gas produced by the action of acid on a carbonate forming part of an ore would act in precisely the same manner as carbonic acid gas produced by the action of a carbonate added to the ore. This fact was recognized by Sulman and Kirkpatrick-Picard, two of the grantees of the patent in suit in patent 788,247, in which they state that if the ore contains a carbonate, any small excess of acid will liberate carbonic acid gas or that a suitable carbonate may be initially added to the ore for that purpose. Froment in his British patent 12,778 of 1902 gives two examples, in one of which a carbonate is added to the ore and in the other of which the ore naturally contains (206—131) carbonates. "Limestone" referred to by Froment in his first example is "calcite," which is specified as present in the ore of the second example.

An argument was filed in the United States Patent Office under date of December 31, 1904, by Cattermole, Sulman & Kirkpatrick-Picard in their application for United States patent 788,247, Sulman and Kirkpatrick-Picard being two of the three joint grantees of patent 835,120 in suit. In their letter of December 31, 1904, Cattermole, Sulman and Kirkpatrick-Picard explain that in carrying out their flotation process upon which patent 788,247 was eventually granted, they "only seek to coat every particle of metalliferous matter as thinly and evenly as possible." In view of this statement the process of the patent in suit and the process of patent 788,247
230 were both based on initial oiling of the mineral particles by a bare film, and the same was true of Cattermole, Sulman & Picard process set forth in their patent 777,274, which is referred to in patent 788,247.

I should say, therefore, that the statement in the patent in suit, referring to patent 777,274—

"We have found that if the proportion of oily substance be considerably reduced—say to a fraction of one per cent on the ore—granulation ceases to take place,"

was based on a misapprehension or error as to the proportion of oil actually contemplated in patent 777,274, or its complement 788,247.

I have thoroughly examined different portions of the Black Rock mine of the Butte & Superior Copper Co., the ore from which mine was operated upon by defendant, which operations were made the basis of the charge of infringement in this suit. Throughout the mine I found manganese (207—132) carbonate, rhodochrosite, which was easily recognizable by its pink color. The manganese carbonate occurs in many places in large veins and masses sometimes several feet in width, and often occurs in the body of the richest blende or zinc sulfid. The ore in the railway cars waiting for treatment had manganese carbonate distributed throughout.

I have performed experiments with the full size flotation plant at

the Basin, Montana, mill of the Butte & Superior Copper Company for the purpose of determining the conditions of the quantity of oily matter and acid and other conditions necessary to the successful operation of the flotation process of the character conducted in the experimental machine at Basin, Montana, as described by defendant and by Jesse C. Gibson in their testimony in this suit.

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(Complainants objected to Dr. Byrnes' testimony describing his experiments in any full size flotation plant upon the ground that a defendant may not retain a machine in secrecy and refuse the reasonable demands for inspection thereof by opposing counsel, and nevertheless ask the Court to pass upon questions involving the processes carried on in such machine for the purpose of relieving the defendant from a charge of infringement.)

I spent a number of days at this mill, the first day being Monday, April 8, 1912, and the last one Sunday, April 14, 1912. During this period I thoroughly examined the entire mill, from the bins where the ore is delivered to the crusher to the final Callow cones, which produce the thickened ore-pulp delivered to the Hyde flotation plant. This flotation apparatus itself, which is a distinct (208—133) department of the mill, I saw operated, and myself operated, under different conditions on different days.

The Hyde apparatus consists of two duplicate or identical portions, arranged along opposite sides of an intermediate platform or alley. One of these portions was used to produce a diluted froth containing so much of the zinc sulfid as can be floated, which as I recall may be upwards of 90 per cent of the ore-content, and is colloquially termed the "rougher." The other duplicate portion is used to thicken the concentrate froths delivered by the rougher, and is termed the "cleaner." By reason of the identity of these two portions or sections of the plant, their functions may be interchanged, i. e., either side may be used as the "rougher" and the other as the "cleaner." Each duplicate section of the apparatus extending as stated along one side of the intermediate alley, consists of three units, which are termed "cells," comprising one or more agitator vessels and a flotation box. The first "cell" has three agitator vessels arranged side by side, and communicating at their lower ends, the first receiving the thickened ore-pulp, elevated from the Callow cones, and the last delivering the oiled and aerated pulp to a flotation-box. Each agitator vessel is a square wooden-box, within which depends a centrally revoluble shaft carrying at its lower end four radial stirring arms. The ore-pulp fed into the first agitator vessel, initially having a temperature of about 3 degrees above the freezing point of water, during the time I was at the plant, is warmed to a temperature sufficient to keep the oiling agent fluid and thin, by the injection of steam. The oiling agent, being the "red oil," or impure oleic acid, received in iron drums from Charles T. Perry & Co., of Helena, Montana, is melted out of the drums (209—134) by rolling them onto a set of steam-coils and by injecting live steam into the drum. The liquid oil is then poured into an iron tank, itself

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steam-heated, located at the side of but on a higher level than
233 the first agitator vessel. This tank has an outlet leading from its bottom and delivering into the vessel, the rate of feed being regulated by a stock-cock in the outlet pipe. The pulp is warmed, oiled and agitated in the first vessel, thence delivered into the second vessel and further agitated, thence into the third vessel and agitated, and is thence delivered through an iron pipe into the side of the flotation-box, which in use is filled with water. The level of the water in this box can be regulated by a valve, and is kept at such height that a thin layer of water at the top, together with the froth of concentrates floating thereon, is continuously delivered over the transverse skimming lip extending across the front end of the box, whence the water and froth fall into a launder.

The pulp minus the first froth is continuously withdrawn from the lower end of the flotation-box to the second "cell" of the "rougher," which is identical with the first cell, except that it employs but two agitator vessels, delivering to a second flotation-box. A second froth is taken off from the second box and delivered to the same launder as the first froth, and the subsiding pulp minus the two froths is lifted and delivered into the single agitator vessel of the third "cell." A final froth is then removed from the (third) flotation-box of this cell, and is delivered into the same launder. The three froths are delivered by the launder to the "cleaner" portion of the plant, which is a duplicate of the "rougher." The water and tailings from the third flotation-box of the "rougher"
234 are discharged as waste. The color of the tailings (210—135) in this waste gives a very accurate idea of the amount of the metalliferous constituent, blende, which has been removed from the ore. If the "rougher" is operating properly, and the proper amounts of oil and acid are being supplied to the pulp, these tailings are almost white, whereas the original pulp is quite gray, by reason of the blende content. If the oil is fed in excess, it appears in the tailings, associated with particles of blende, which I could hardly call "granules" on account of their small size, although doubtless several oiled particles adhere together to form the small specks or flecks which I observed when the pulp was over-oiled. Excess feed of oil is also at once shown by the character of the froths rising on the flotation-boxes, which then become thinner, less heavy and viscous, and present a shiny, oily appearance, with fewer and larger entangled air-bubbles, instead of innumerable fine bubbles.

In the regular operation of the plant, there is no measurement, nor is there any means for measurement, of the amount of oil and acid supplied to the pulp, the feed of both being regulated from time to time to give the best results in the production of heavy froths and clean tailings. The acid, a 25 per cent solution of sulfuric acid, is fed into the ore-pulp before it is delivered to the "rougher."

The "cleaner" receives the three froths from the "rougher," fed into the first of the three agitator vessels of its first "cell." After successive agitation in these three vessels, the froths, including
235 the water which was discharged with each of them from the rougher cells, is delivered into the corresponding flotation-

box, where a very heavy froth, several inches in thickness, rises, and is discharged (211—136) over the skimming-lip, without any accompanying layer of water. The subsiding liquid is delivered from the bottom of the flotation-box to the first of the two agitators of the second cell. A second froth is taken off in its flotation-box, and the tailings are finally reagitated and defrothed in the third cell, the tailings from the third flotation-box of the "cleaner" being then elevated and returned to the first agitator of the second cell of the "rougher."

On my first visit to the plant I observed the temperatures of the pulp in the three flotation-boxes of the "rougher," inserting a chemical thermometer through the froth in each and downward about one foot into the liquid: the temperature in the first box was 28° C., and in the second and third 27° C. each. I also took the temperature in the three flotation-boxes of the "cleaner" and found them to be, respectively, 27.5°, 28° and 29° C. Later, at my request, the supply of steam to heat the entering ore-pulp was decreased, so that for a period of about half an hour the temperature in the three "rougher" boxes was 22° C., within a fraction of a degree in each. The froths still remained fairly heavy, and the tailings from the third box light-colored, but containing considerable mineral.

236 I then had the temperature raised by a supply of more steam, so that the temperature in each box was 24° C., within a fraction. The froths were then quite or fairly heavy, and the tailings white or fairly clean, though not as good as when the temperature was 27° or 28°. These results were to be expected on account of the fact that the "red oil" used becomes thick and viscous at lower temperatures.

On another day, the "rougher" was entirely emptied, both agitators and flotation-boxes. Operations were then (212—137) resumed, the pulp entering the first agitator at a temperature of about 3° above freezing, before the steam was admitted. The pulp was then heated until its temperature in the first flotation-box was 30° C., and about the same in the other two. For the purpose of experiment, I had the iron vessel supplying "red oil" to the first agitator emptied before beginning this run, and supplied it with cotton-seed oil, not heated. I then ran this oil into the agitator at about three times the rate of feed which was customary with the "red oil," obtaining good froths. The tailings were also quite good, though containing some mineral. I then opened the valve in the oil-discharge pipe to its full capacity, allowing about seven times the normal feed of oil to flow, also separately adding to the agitator a few per cent, proportionate to the cotton-seed oil, of the "red oil," warmed to make it liquid. I then obtained very good heavy froths and very clean tailings, as good, I think, as I saw produced at any time when I was at the mill. It is thus apparent that different oils can be used, in widely different proportions, as I also found in my tests with the Hyde slide apparatus.

237 I did not use any upcast or upcurrent of water in my operations with the full size flotation plant.

I do not know of any oil-gas flotation process for the separation

of minerals ever having been commercially operated in this country other than the operations of Hyde.

Dr. Chandler's conclusion as to the amount of oil being used upon the occasion of Mr. Nutter's visit to the plant at Basin, Montana, was based on pure speculation and was a guess. Dr. Chandler in his calculations "assumed that that concentrate represented one-third of the original ore" and also "assumed one-third as much more for * * * loss on the tailings." There was no warrant whatever for these (213—138) assumptions. As Mr. Nutter made no observations whatever at the time of his visit as to the oil supplied to the material treated; as the material being treated at the time of Mr. Nutter's visit was vanner concentrates of unknown composition and grade, unknown ratio to the ore or ore pulp ordinarily treated and not representative of the ordinary pulp feed; as these concentrates were simply dumped into mixer 1, by buckets in an irregular and haphazard manner; and as the amount of mineral and oil which went into the tailings was unknown; I am clearly of the opinion that no legitimate conclusion whatever can be drawn from the percentage of oleic acid in the handful of froth taken away by Mr. Nutter, as to the ratio or percentage of oil relative to ore employed by the defendant, or as to whether or not it was within the limits specified in the patent in suit.

238 Aeration of a liquid by agitating it in the presence of atmospheric air and beating the air into and through it in the form of fine bubbles, to produce a froth, is an every day operation with which we are all familiar, such as the domestic operations of beating of eggs and whipping of cream, and the soda-fountain operation of producing "milk shake." It is customary in various arts to thus aerate liquid; for example, it is common to aerate soap while in the molten or liquid condition, to produce a material which will be light and float when solid. An agitator for this purpose, of the general type employed by defendant, is shown in an old book on the manufacture of soaps which I happen to have at hand. I refer to "A Treatise on Chemistry, Applied to the Manufacture of Soap and Candles," by Campbell Morfit, copyrighted in the year 1856 and published in Philadelphia in 1860, by Henry Carey Baird, pages 271-272, "Flotent Soaps," and the accompanying figures 54 and 55. It is common in the production of butter to churn and beat air (214—139) into the milk, the air diffused throughout it acting to throw down the curd and separate it from the butter. I refer, for example, to U. S. patent No. 373,113, granted November 15, 1887, to H. J. Wagner, page 2, lines 6-30, and instances of these methods might be indefinitely multiplied.

(It was stipulated that the book by Campbell Morfit referred to by the witness was published and circulated during the year 1860.)

The following documents, papers and apparatus referred
239 to by defendant's witnesses were introduced in evidence:

Pages 271 and 272 of the book referred to by the witness as "Defendant's Exhibit Extract from 'Treatise on Chemistry Applied to the Manufacture of Soap and Candles.'"

Printed Patent Office copies of the following named patents, respectively designated with the words "Defendant's Exhibit," and the title of the patent, as follows:

Bradford Patent No. 345,951.
Everson Patent No. 348,157.
Wagner Patent No. 373,113.
Hockley Patent No. 466,753.
Rouse Patent No. 469,599.
Hebron & Everson Patent No. 471,174.
F. E. Elmore Patent No. 653,340.
F. E. Elmore Patent No. 676,679.
A. S. Elmore Patent No. 689,070.
A. S. Elmore Patent No. 692,643.
Stoveken Patent No. 729,805.
Delprat Patent No. 735,071.
Glogner Patent No. 736,381.
Good Patent No. 745,960.
Delprat Patent No. 768,035.
Kendall Patent No. 771,075.
Potter Patent No. 776,145.
Cattermole Patent No. 777,273.
Cattermole, Sulman & Picard Patent No. 777,274.
Cattermole, Sulman & Picard Patent No. 788,247.
Sulman and Picard Patent No. 793,808.
240 Schwarz Patent No. 807,501.
Schwarz Patent No. 807,503.
Kirby Patent No. 809,959.
Sulman Patent No. 835,143.
Sulman, Picard and Ballot Patent No. 835,479.
Kirby Patent No. 838,626.
Sulman, Picard and Ballot Patent No. 879,985. (215—140)
Hyde Patent No. 1,022,085.
British Patent to Lake (Froment) No. 12,778 of 1902.

It was stipulated that this Lake (Froment) British patent was sealed on August 18, 1903.

Certified copies of the File-Wrapper and Contents of the following patents, each so marked and with the title of the patents as follows:

Cattermole, Sulman & Kirkpatrick-Picard Patent No. 788,247.
Sulman & Kirkpatrick-Picard Patent No. 793,808.
Schwarz Patent No. 807,501.
Schwarz Patent No. 807,503.
Kirby Patent No. 809,959.
Kirby Patent No. 838,626.
Patent in Suit, No. 835,120.

One of the two duplicate slide machines referred to and used by the witnesses J. M. Hyde and E. A. Byrnes, as "Defendant's Exhibit Slide Machine."

The apparatus referred to by the witness E. A. Byrnes as having been made in accordance with Figure 1 of the drawing of the patent in suit as "Defendant's Exhibit Apparatus of Patent in Suit."

241 Sketch referred to by the witness Hyde as "Defendant's Exhibit Hyde Sketch."

The apparatus referred to by the witness E. A. Byrnes as having been made in accordance with Figure 1 of the drawing of Sulman and Kirkpatrick-Picard patent No. 793,808, as "Defendant's Exhibit Apparatus of Patent No. 793,808."

It was noted by complainants' counsel relative to the file-records of the patents other than the patent in suit that statements made during the prosecution of these applications for patents (216—141) were objected to as irrelevant and immaterial to the issues herein. The formal objections as to patents not set up in the Answer were repeated.

It was stipulated that copies of the documents which were marked for identification during the taking of the deposition of the defendant, James M. Hyde, may be offered and used in evidence in place of the original documents, subject to the production of the originals upon reasonable demand.

Cross-examination de bene esse, not waiving the objections and notice heretofore stated and given:

During the ten year period when I was Principal Examiner of the Division of Metallurgy and Electro-chemistry in the United States Patent Office, the number of Principal Examiners in the Patent Office varied from about twenty-five to thirty-five.

The Hockley patent was referred to by me as a disclosure
242 of the well known fact that finely divided gold and silver will float on water, illustrating the principle of surface tension flotation.

The four Elmore patents offered in evidence relate to the flotation of mineral by oil per se, rather than gas. I cited two of them as illustrations of the preferential affinity of oil for mineral; and one, No. 689,070, as an illustration of the use of a very small amount of acid to increase the preferential affinity of oil for mineral. The flotation processes described in these Elmore patents do not rely on aeration or the evolution of a gas.

The Bradford patent describes the flotation of unoiled finely divided minerals. Such particles may float on water (217—142) because not wetted or only slightly wetted, lying on the surface of the water as on an actual skin or thin membrane, slightly depressed beneath them. A film of oil or grease on the surface of a sewing-needle tends to prevent actual contact of the needle with water, and thereby brings into play the phenomenon of support by surface-tension. Doubtless in this case, also, there is a film of air surrounding the film of oil or grease.

The Potter and Delprat patents do not deal with oiled particles.

In Experiment 4 of my seven numbered experiments in connection with the Froment patent, I used, I think, about five drops of concentrated acid and measured them only by counting the drops. The mixture was heated by placing it in the warm water

running from the spigot at the sink. I did not take the
243 temperature by a thermometer. In Experiment 5 I did not weigh the single drop of olive oil. The same amount can be obtained by dropping the oil from a burette such as I used. This burette was one of the usual kind, having a cylindrical bore about one foot long, designed to deliver one cc. and graduated in tenths of a cubic centimeter. In Experiment 6 I used warm water from the spigot as before to a temperature not measured by a thermometer. In Experiment 7 I used about five drops of concentrated sulphuric acid as delivered by the ordinary 50 cc. burette having a glass stopcock. This burette was used for dropping sulphuric acid in all of my seven experiments.

In carrying out my test corresponding to that of the Kirby patent No. 809,959, I agitated the mixture in the slide machine, rotating the agitator at a speed of about 1,600 revolutions per minute. I measured this speed by a tachometer. (218—143)

In my experiment carrying out the process of the Schwarz patents Nos. 807,501 and 807,503, I used the same speed of rotation of the agitator, 1,600 revolutions per minute, and this is also true as to my test carrying out the operation of the Everson patent No. 348,157.

My tests of "Defendant's Exhibit Apparatus of Patent No. 793,808" were carried on both in Butte, Montana, and in Washington, D. C., and in each case I drove the apparatus by a belt from the stepped cone of an engine lathe. I shifted the belt from step to
244 step until I obtained as high a speed as possible, without the belt slipping or throwing off. I had no means at hand at either place for measuring the speed, but judge that it was several hundred revolutions per minute.

In my tests under the process of the Froment British patent using the Hyde slide apparatus, in general the first agitation was for a period of thirty seconds and the subsequent agitations about ten to twenty seconds. The speed of the agitator was about 1,600 revolutions per minute.

In my tests of "Defendant's Exhibit Apparatus of Patent in Suit," the cone mixer was driven by the same electric motor as that used with the Hyde slide machine, having a speed of 1,600 revolutions per minute. The pulleys on the shaft of the motor and cone agitator were about the same size. I ran the cone at as high a speed as I could without the quarter inch round belt slipping, increasing the tension slightly on the belt as the agitator ran more heavily. There was some tendency for the cone to clog with ore and also for ore to work into the step at the lower end of the agitator shaft and increasing frictional resistance. This step ground out considerably in use, however, so that (219—144) the shaft did not bind so much in the later work. I did not measure the speed of rotation of the cone shaft during this test. I could not keep the tachometer on its upper end, on account of its lateral vibration. The standard carrying the bearings for the upper end of the shaft was not sufficiently inflexible to hold the bearings rigidly in place.

X Q. 60. You have made the positive statement that
245 the slide machine used by you in your tests was "designed in part by the defendant." What is the source of your knowledge of this fact?

A. The defendant.

I performed my various experiments with the ore in the Black Rock mine of the Butte & Superior Copper Company for the reason that this was the ore used by defendant in the operations which formed the basis of the charge of infringement in this suit.

By the expression "oil-gas flotation process" I have understood a process for the flotation of the metalliferous constituents in an ore, based upon the preferential affinity of oil for this constituent and of gas for the oil, that is, one in which the mineral particles are oiled and are then floated by attached bubbles or films of air or gas. I should say that the following patents referred to by me describe oil-gas flotation processes, that is, processes in which the mineral particles are oiled and then floated by attached bubbles or films of air or gas:

348,157 to Everson.
736,381 to Glogner.
745,960 to Good.
788,247 to Cattermole & Kirkpatrick-Picard.
793,808 to Sulman & Kirkpatrick-Picard.
807,501 to Schwarz.
807,502 to Schwarz.
809,959 to Kirby.
838,626 to Kirby.
British 12,778 of 1902 to Froment. (220—145)

The amounts of oil specified in the Cattermole patent
246 777,275, and in the patent in suit, overlap each other, or may be the same as applied to many ores, and since precisely the same cone agitator is used in both, the two processes may become identical. While Cattermole describes his process as one of agglomerating the oiled mineral particles into heavy granules which sink, and while the patentees in suit describe their process as one of aerating and floating oiled mineral particles, it is obvious that when the same amount of oil is used on the same ore, with the same agitator, the same conditions will give the same result in both cases, so that the Cattermole process will float the same amount of mineral as the process in suit. In view of my experiments in which I used amounts of various oils as great or greater than the percentages specified by Cattermole, when based on the weight of metalliferous mineral matter present in the "Black Rock" ore, with a more efficient agitator than that shown by Cattermole and adopted by the patentees in suit, and obtained a very high recovery by aeration and flotation of the oiled mineral. I should say that the process of this Cattermole patent itself, at least as applies to the "Black Rock" ore and with the kinds of oil used by me is one of oil-gas flotation, and my opinion would equally apply to the process of the Cattermole, Sulman and Kirkpatrick-Picard patent 777,274.

I think the process of Elmore patent 676,697 and 689,070 has

been commercially tested in this country, though I am not positive.

247 I am quite sure that processes of the type described in Delprat patent 735,071 and Potter patent 746,145 have been used in this country, although I do not recall where or to what extent, aside from the method of this type used by one of my own clients. I think the (221—146) process of the Kirby patents 809,059 and 838,626 has been operated in this country or Canada, but whether or not to an extent that would be termed "commercial" I do not know, and this is an impression rather than a recollection. I have no positive recollection as to whether these processes are in use at present in this country.

(Dr. Byrnes in cross-examination gave details of the construction of the large sized plant at Basin, Montana, examined and tested by him in April, 1902.)

X Q. 77. In describing your first test with cotton-seed oil in this apparatus, you say that you ran the cotton-seed oil into the agitator at about three times the rate of speed which was customary with the red oil. How did you determine that this was the rate of feed?

A. By measuring the two rates.

X Q. 78. And how did you measure them?

A. By noting the amount discharged into a glass cylinder graduated in cubic centimeters, in a noted time, fifteen or thirty seconds.

X Q. 79. What did you thus determine as the rate of speed in each instance?

A. While I can hardly say that there is any "normal" rate of feed for the red oil, I did determine this rate on different

248 occasions, finding it to be, in one test, about 100 cc. per minute, and in another about 120. In using cotton-seed oil, I first ran at 300 cc. per minute, which I denominated "three times the rate of feed which was customary with the red oil." I afterwards ran with the valve open to its full limit, then discharging 735 cc. per minute, to which I added, in a separate stream, 30 cc. of red oil per minute.

X Q. 80. Did you measure the rate of feed or the state of dilution of the pulp which was fed to the first agitation (222—147) vessel?

A. No.

X Q. 81. Did you measure the amount of concentrates or the amount of tailings discharged from the apparatus in any given time?

A. No. Both the feed of pulp and discharge of froths and tailings was quite variable, necessitating constant regulation of conditions. The operations being continuous, I did not attempt to interrupt them to determine if these was any average rate of supply or discharge of froths and tailings.

X Q. 82. What would be your estimate of the hourly or daily capacity of the apparatus expressed in any terms?

A. I could not give even an approximate figure.

X Q. 87. Did you measure the speed of rotation of the agitator blade of this apparatus?

A. No.

X Q. 88. You are familiar, are you not, with a publication in the Engineering & Mining Journal, of November 15, 1890, relative to the Everson process?

249 A. Yes, assuming that you refer to the article on page 581. (223—148)

As a Stated Term of the United States District Court in and for the District of Montana, held at the Courthouse in Butte, Montana, this 6th day of July, 1912.

Present: Hon. George M. Bourquin, Judge.

In Equity. No. 1076.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,

vs.

JAMES M. HYDE, Defendant.

Order.

On motion of defendant, and on reading and filing the stipulation hereto annexed, and with the consent of the complainants, it is

Ordered, that a commission be issued in this cause out of this court, directed to Joseph Phillips Crawley, of 9 Bishopsgate, London, England, a Notary Public, residing in London, England, to examine the following named persons under oath as witnesses herein, viz:

Henry Livingstone Sulman, Hugh Fitzalis Fitzpatrick-Picard, John Ballot, D. P. Mitchell, Francis E. Elmore, Alexander S. Elmore, Herbert C. Hoover, Theodore J. Hoover, and such other witnesses as defendant shall desire to examine. It is further

250 Ordered, that the examination above provided for shall take place during the months of August and September in the year 1912. It is further

Ordered, that either party to this action may examine not only the witnesses herein named, but any other witnesses (224—149) that either party may desire to examine in Great Britain; provided, however, that the names of said witnesses and their places of residence shall be given to counsel for the opposing party in England not less than two days prior to the examination of each of such witnesses, and provided further that the examination of witnesses in behalf of defendant shall be first completed and closed and defendant's testimony closed, and that thereafter complainants may examine either of the said witnesses or other witnesses in rebuttal of defendant's testimony taken in the United States or under the commission. It is further

Ordered, that counsel for each of the parties hereto shall give notice to opposing counsel, before the taking of depositions under this order shall be commenced, of his address in London, and delivery of notices herein provided for at such address shall constitute sufficient service thereof. It is further

Ordered, that, all directions herein contained as to time, place, order and manner of examination of said witnesses, may be changed or modified by written consent of counsel for the respective parties, and that by written consent of counsel the examination of said witnesses may be conducted by and before a Notary Public
251 or other official authorized to administer oaths other than the Commissioner herein particularly designated. It is further

Ordered, that the examination of all witnesses under this commission shall be oral, or taken by question and answer in the usual manner of taking oral depositions by examination, cross-examination, and redirect examination; that the testimony given under such examination shall be reduced to writing, signed by the witnesses and certified by the Commissioner, and by him transmitted by mail (225—150) to the clerk of this court at the City of Helena, Montana, unless otherwise mutually agreed upon by said counsel for both parties. It is further

Ordered, that all testimony taken under the commission provided for herein shall be taken subject to all legal objections at the trial of this action.

GEORGE M. BOURQUIN,
Judge of the District Court for the District of Montana. (226—151)

United States District Court, District of Montana.

In Equity. No. 1076.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,
vs.
JAMES M. HYDE, Defendant.

Stipulation.

It appearing that the defendant wishes to examine on open
252 commission, at London, England, the witnesses whose names are stated in the preceding proposed order, and such other witnesses as defendant shall desire to examine, with the expectation of proving, particularly, the following facts:

1. That the patent in suit does not disclose anything that was not well known to the public long prior to the date of said patent.
2. That the patent in suit does not set forth an operative process, or one that has ever been of commercial utility.
3. That such commercial operations as have been conducted by

the complainants have not been in accordance with the process set forth in the patent in suit.

4. That the patent in suit is deceptive and void under the provisions of R. S., Section 4920.

5. That the defendant was not, while in the employ of Minerals Separation, Limited, one of the complainants, instructed by the joint patentees or by other engineers and experts in the employ of said Minerals Separation, (227—152) Limited, in technical details and particulars as to the patent in suit and the installation and use of the process of ore concentration set forth therein.

6. That the three joint patentees are not the original and joint inventors of anything set forth and claimed in the patent in suit.

And it also appearing that the complainants desire to examine witnesses in London in rebuttal of defendant's testimony as heretofore taken in the United States, or as it may be brought out
253 under this commission in the testimony taken in London;

And it also appearing that the witnesses named, and others who may be able to testify relative to the alleged facts as above and in rebuttal, cannot be examined in the United States, and that the facts which defendant expects to prove in support of his defense, and that the facts which complainants expect to prove in rebuttal thereof, cannot be adequately or completely proved by witnesses within the United States;

It is hereby stipulated, consented and agreed by and between counsel for the respective parties that the preceding order may be entered and filed and a commission be issued pursuant thereto.

McCONNELL & McCONNELL,
Solicitors for Complainants.
KREMER, SANDERS & KREMER,
Solicitors for Defendant. (228—153)

Testimony for Defendant of Henry Livingstone Sulman.

LONDON, ENGLAND, August 6-9, 1912.

Direct examination:

I am 51 years of age, a resident of London, and a consulting metallurgist and assayer by occupation. I am the Henry Livingstone Sulman who is one of the grantees of United States Patent No. 835,120 in suit.

I first learned of the use of oil to separate particles of mineral of an ore by flotation due to the buoyancy of oil in about June,
1894. I first learned of the concomitant use of gas with an
254 oily substance and as an essential concomitant to flotation about July, 1903. I do not here refer to the more or less accidental presence of some air bubbles in the Elmore oil buoyancy process, but, prior to this, I had noticed the tendency of oiled mineral to float at a water surface or when brought into contact with bubbles of air during the prosecution of researches into the Cattermole process. In carrying out the Cattermole process, wherein the

metallic constituents are formed into granules in an aqueous pulp by means of oil, these granules being of sensible size can be separated from the gangue material of lower specific gravity in a water upcast. It was noticed under certain conditions that if air bubbles were introduced by accident into such upcast, they would tend to float up some of the granules and also some of the insufficiently oiled mineral to the top of the upcast, where they were lost by being carried away with the gangue. This was always regarded by us during the first stage of the Cattermole process development as a disadvantage to that process and means were taken subsequently to again sink any metallic portions so floated.

As to the intentional use of a gas with an oily substance (229—154) to produce flotation, referred to by me as first known to me about July, 1903, this process was originated by Mr. Picard and myself and devised in the laboratory of my firm, and it was only experimentally tried on a small scale. At a later date Mr. Cattermole co-operated with us in a further development. In this
255 process an ore pulp was mixed with a small quantity of oil, insufficient to float the mineral by the buoyancy of the oil alone and mixed sufficiently to ensure the attachment of small quantities of oil to the mineral. A gas was then liberated in or generated in the pulp so prepared and it was found that such gas had a tendency to attach itself to the oiled particles. If air were used this was liberated by blowing a stream of bubbles through the mixture in several ways, and if a gas other than air were employed, this was generated in the liquor by chemical reactions or by electrolysis.

I subsequently found that this knowledge had been antedated by Mr. Froment. I first learned of the Froment process from the abstract of the Froment British patent which was published in the Journal of the Society of Chemical Industry, and which I saw in August, 1903. I have only seen the Froment process operated and have only operated it myself on a small scale in the laboratory. My experiments on the Froment process were confined to test tubes, bottles or somewhat larger vessels. A somewhat larger apparatus was obtained from Mr. Froment at some later date, but I never saw it effectively worked. Efforts were made to work this apparatus, but with no successful result.

We made experiments following instructions given in the specification of the Froment British patent. We added ore to water to form a freely flowing pulp, and also added to this a substance capable of being decomposed by a dilute (230—155) acid for
256 the purpose of generating a gas, such, for example, as calcite, whiting, or carbonate of soda. A quantity of oily matter sufficient to form a thin layer was then added upon the surface of the pulp and the whole was then well mixed. A small quantity of acid was then added to the mixture with suitable gentle stirring to bring the acid and the gas-producing substance into contact, and thereupon the oiled mineral was floated to the surface by the bubbles of the generated gas.

Q. 14. Did you follow Froment's instructions contained in his

British specification 12,778 of 1902 in the matter of agitating the mixture of the ingredients you have named?

A. I did agitate gently for the purpose I have stated, that is, to bring the acid into contact with the decomposable substance. A greater degree of agitation was found harmful in producing the flotation as the type of float material produced was such as very readily broke up, in my experience, and anything like vigorous agitation defeated the object of the invention.

In my experience agitation in the Froment process should be given in two stages, in the first stage to get the oil into efficient contact with the mineral to be subsequently floated. This first agitation is not responsible for the production of the float material required. The second state is for the purpose of effecting due contact of the acid with the decomposable carbonate, and much less agitation is required and, in my experience, is necessary, in this second
257 stage, having regard to the nature of the float material produced.

The first requisite of any oil concentration process is to obtain efficient contact between the oil and the mineral and suitable methods must be employed to effect (231—156) this. Where the oil is in large relative quantity to the mineral violent agitation is unnecessary and may be very harmful. With decreasing proportions of oil more vigorous agitation or mixing is necessary to ensure such efficient contact of oil with the mineral particles. The agitation may therefore be said to be roughly proportioned to the work to be done in bringing about contact between large or small quantities of oil in regard to the mineral.

In August, 1903, when I first learned of the Froment process, I was associated with the various gentlemen who formed Minerals Separation, Limited, or with Minerals Separation, Limited, if it was then incorporated. In operating the Froment process, we tried a large variety of oils, hydrocarbons, heavy and light, certain fatty oils also. Specifically, so far as I can now recall, we used heavy and light lubricating oils, cylinder oils, lighting oils and even light volatile hydrocarbons. I think also of turpentine and oleines. There were doubtless others, but I do not recall them specifically. Every effort was made to locate the factors which would make the Froment process successful and I know that a variety of oils were, therefore, experimented with to this end.

258 Q. 22. What kind of an apparatus did you use when you first operated, or saw operated by others, the process set forth in the patent in suit?

A. The apparatus that I first saw the agitation froth produced in as described in the specification referred to was the ordinary gabbet apparatus consisting of a vessel with rotating cone and with suitable baffles. The cone was rotated at a high rate of speed, about 1000 revolutions per minute, and the size of the vessel was such as would contain about 2 litres of liquid (232—157)

Q. 23. How was the concentrate removed from the remainder of the material when this apparatus was used?

A. When I first saw this thick froth produced it was so coherent

and resistant that we were able to remove the greater portion by spooning it or ladling it from the surface of the liquid. But this was necessarily an imperfect method and a funnel with a long stem was then introduced into the liquid below the froth and water poured in through the funnel until the froth was floated over the rim of the containing vessel and the overflow caught in a basin placed beneath it.

This operation took place in the experimental laboratory of Minerals Separation, Limited, at Aldermanbury Avenue, London, E. C. Subsequently we fitted a spitzkast or spitzlutte apparatus to the battery of agitation vessels and at the end of the series of these, upon which spitzkast or spitzlutte the agitation froth was floated
259 off and the gangue allowed to sink. This apparatus was substantially the same as that illustrated in Figure 1 of the patent in suit, although this diagram appears to somewhat emphasize the height and length of the pipe H and, for the purposes of the illustration, the spitzkast shown is placed in the reverse direction to the flow of the current through the battery. At first an upcurrent of water was maintained in the several spitzkasten for the purpose of separating the gangue into heavier and lighter sands and slimes. Subsequently the spitzulette were replaced by spitzkasten where no upcurrent was used. The battery of agitation vessels had been working in connection with the Cattermole process and was already installed when we constructed this apparatus like that illustrated in Figure 1 of the patent in suit. A very efficient froth formation and separation (233—158) was obtained by us in this apparatus in Aldermanbury Avenue.

When I first saw the process operated according to patent 835,12[illegible] in suit, Mr. Ballot was present and the experiment was being performed by Mr. A. H. Higgins. At some date a week or two prior to the discovery of the air agitation froth, Mr. Ballot, Mr. Picard and myself had been in close consultation as to a number of factors which we considered required final investigating and quantifying. They concerned mainly the operation of the Cattermole process, but we also had in view the clearing up of a number of loose-end observations noticed in previous developments of oil concentration
work. Mr. Ballot, Mr. Picard and I found it necessary to
260 draw up a schedule of such factors as we considered required investigation, and we instructed the experimental staff to carry these out. The carrying out of these final investigations was done under the immediate supervision of one or other of us throughout the whole of them. The factors to be investigated were as follows. In a report dated March 3, 1905, made by Sulman & Picard and addressed to John Ballot, was recorded the work which the whole three of us were doing then, and this report was not so much for the information of Mr. John Ballot as the putting on record of work which he and we had jointly done, for purposes of reference afterward. I quote the following from the report:

"We are in full agreement with the rest of Mr. Higgins' observations and may summarize the work now being done at Aldermanbury Avenue as the determination of the following factors:

1. Influence of acidity on granulation.
2. Influence of temperature on ditto.
3. Influence of speed of gabbet agitation on granulation.
4. Influence of ratio of ore to liquor on granulation.
5. Influence of metallic salts on granulation. (234—159)
6. Influence of the size of particles and of the influence of slimes on granulation.
7. Influence of the amount of oil on granulation.

261 The above factors are being determined on
(*a*) Oleic acid.
(*b*) Residuum oils.

Mr. Higgins' present report is therefore the first installment of the above scheme of trials."

Mr. Higgins was sending in in like fashion to Mr. Ballot the daily records of these trials proceeding under the joint supervision of the three of us. It was in the carrying out of the latter factor, namely, the amount of oil in its effect upon granulation, that in reducing the amount used beyond all previous quantities in regard to the mineral, that we found granulation to decrease or even cease when a certain limit was reached, and that coincidentally a mineral froth began to take its place. When we decreased the amount of oil to about .6 per cent upon the ore, granulation had ceased to appear and a very considerable proportion of mineral was found to float to the surface as a thick froth. We still further decreased the amount of oil until we found that with .2 to .1 per cent of oil on the ore practically the whole of the mineral came to the surface as a thick blackish matted froth.

At the request of counsel for the complainants the Commissioner marks for identification the document referred to by the witness in his last answer as "Sulman and Picard Report March 3, 1905."

Q. 34. Can you remember at this date the substance of Mr. Higgins' report which you refer to in the document identified as
262 "Sulman and Picard Report March 3, 1905," or, if you can, will you produce that report?

A. This report has been handed to me by counsel and before referring to it I will state that at this date the (235—160) discovery of the agitation froth had not been made. Mr. Higgins' report therefore deals with some of the prior factors of granulation set out by us in our schedule of items to be investigated. Mr. Higgins' report is dated March 2, 1905, and is headed "Report on the Conditions of Granulation." It deals in detail with the results of (1) the influence of acidity in granulation, (2) upon the influence of heat on granulation, setting forth in detail the experiments which he tried under the directions he received, (3) with the influence of the thickness of the pulp, and (4) with the influence of peripheral velocity of cone. On the last page of his report he notes that experiments are also to be carried out on the influence of the quantity of oil present in order to complete the information regarding granulation.

At the request of counsel for the complainants the Commissioner

marks for identification the document referred to by witness in his last answer as "Higgins' Report March 2, 1905."

Q. 35. Do you remember whether Mr. Higgins made any report setting forth the result of his investigation of the seventh topic named by you, namely, the influence of the amount of oil on granulation?

A. Mr. Higgins submitted a record of the experiments he carried out in the investigations which was sent him by us in regard
263 to the influence of the amount of oil on granulation. This report or record of Mr. Higgins followed the usual course of such reports and was sent in a day or two after the facts had been noticed by us. This report is now handed to me by counsel and bears date March 16, 1905. It is headed "Further Report on the Conditions of Granulation" and under the next heading "Influence of the Percentage of Oil" Mr. Higgins describes the formation of (236—161) the float froth.

At the request of counsel for the complainants the Commissioner marks for identification the document referred to by the witness in his last answer as "Higgins' Report March 16, 1905."

Q. 36. As I understand you, to put the matter briefly, Mr. Higgins was instructed to ascertain the effect upon granulation of varying the various factors of the Cattermole process and that while carrying out these instructions he found that with the quantity of oil too small to properly granulate the concentrates, flotation resulted. Is this the correct understanding?

A. Mr. Higgins was a capable experimenter fully qualified to carry out intelligently all instructions given to him. The instructions given in regard to each of the factors was that they were to be investigated to their full limit in order to quantify and also to explore the limits of application of the Cattermole process. These experiments were carried out by him in the constant presence, although not the continuous presence, of all of the patentees,
264 Mr. Ballot, Mr. Picard and myself, and he recorded the result of such experiments.

Q. 37. Do you mean that while Mr. Higgins was conducting his laboratory work either you, Mr. Picard or Mr. Ballot or more than one of you together were present watching him?

A. I do mean that, although we were not present the whole of the time. Mr. Ballot had his office business to attend to and Picard and myself were also carrying out other investigations on the oil process at our laboratory. Aldermanbury Avenue is situated about 5 minutes' walk from both these officers and one or other of us were constantly (237-162) making journeys backwards and forward to Aldermanbury Avenue to see for ourselves the progress which the investigations were making and which Mr. Higgins was fully competent to carry out on instructions received even when we were not present.

Q. 38. I take it from your last answer that while you, Mr. Picard and Mr. Ballot made occasional visits to the laboratory where Mr.

Higgins was working that Mr. Higgins was alone more or less of the time while conducting his work?

A. He may, and probably was, alone for some periods, so far as Mr. Ballot, Mr. Picard and I were concerned, but others of the experimental staff of Minerals Separation were also present at Aldermanbury Avenue, carrying on other researches which had been set them by ourselves at the same time. Minerals Separation
265 had several capable assistant experimenters, all of whom, or nearly all of whom, had been trained by us in oil concentration work and experiment, and whom we could rely upon to diligently carry out our instructions without supervising them every minute of the time.

Q. 39. Did some of these other members of the staff help Mr. Higgins in the investigation of the seven subjects referred to by you in Sulman and Picard's report of March 3, 1905?

A. My memory is that the other experimenters were engaged on the work other than the seven points mentioned which had been set for Mr. Higgins to investigate, by us.

Q. 40. Were either yourself, Mr. Picard or Mr. Ballot present at the time Mr. Higgins first experimented in pursuance of the instructions set forth at the bottom of page 2 of the Report of March 3, 1905, with an amount of oil falling within the limits designated in United States patent 835,120 in suit? (238-163)

A. Mr. Picard and I were not present at the first discovery that by dropping the oil quantity below the last granulation limit the agitation froth was produced, but I have reason to believe that Mr. Ballot was present, as he came round to my office and at once called me to go with him to see what had been the result of such oil diminution, and I went with him at once. The experiment was again carried out in my presence. I understood that it had been found to occur only a comparatively short time before I was
266 called to see the result of the carrying out of this No. 7 instruction to its further limit.

Q. 41. I take it that this was not the first information you had ever had to the effect that froth flotation could be secured by the use of a very minute quantity of oil; am I right in this?

A. In regard to the formation of a froth of this nature, which is so specific in its character and in the presence of an amount of oil so relatively exceedingly minute as in this instance, this was the first time that I had had experience of any such phenomenon. You have used the word "froth" as if this were a term widely applicable to float material produced at a liquor surface, but it has a very wide and loose use, and is frequently very misleading. If by "froth" is meant an assemblage of bubbles at a liquor surface, such bubbles being separated from each other by a contaminated liquor film, the majority of such froths would be useless for any purpose of separating mineral from gangue. Thus, we may a have a soap froth which will carry but little mineral or gangue, and will differentiate between neither, we may have a saponine froth which will hold neither mineral nor gangue, and many other froths of the same nature. I have heard the float mineral produced by the Froment

reaction described as a froth, but it is a tender and evanescent (239-164) assemblage of bubbles of carbon dioxide carrying mineral, and is not comparable in nature or character with the agitation froth described in the patent in suit. For a froth to be effective at
267 ordinary ranges of temperature between, say, air temperature and well below boiling, the froth must be coherent and permanent for a considerable time. Such froths are typified in my experience only by the agitation froths produced by vigorously agitating an ore-pulp with very minute amount of oil, that is to say, less than one per cent on the ore in the presence of air. Therefore, in answer to your question, this was the first occasion upon which I had seen a heavy thick, matted froth, which was permanent and coherent, produced.

Q. 42. Can you form any idea at this date as to how long a period of time elapsed after Mr. Ballot called your attention to Mr. Higgins' operations under the seventh instruction referred to in the Report of March 3rd, 1905, and the construction and operation of the apparatus which you have described as being substantially similar to that illustrated in Figure 1 of the drawing of the United States patent 835,120 in suit?

A. My memory is that the development of the agitation froth process, and in regard to apparatus to give effect thereto, was proceeded with, with dispatch and interest. If my memory serves, Mr. Higgins for a short time thereafter was engaged in finishing the investigation of one or two factors still outstanding, and my memory further is that others of Minerals Separation staff, among them Mr. Leechman, were occupied in getting together the agitation froth apparatus and experimental plant. This must have occurred in the week or two immediately following the discovery of what
268 happened when oil was employed in quantities (240-165) quite insufficient to granulate the minerals in the pulp.

Q. 43. Referring to your answer to question 17, do you find anything in the Froment patent regarding agitation in two stages; I refer particularly to the example of his process described in lines 33 to 42 of the complete specification?

A. I do not find the two stages of agitation mentioned in the example of Froment put to me, but I was interpreting the specification intelligently and according to the knowledge of any one who had had previous experience in oil concentration work. I think it will be evident that the example quoted would be best carried out if precautions had been taken to bring the mineral into efficient contact with the oil before liberating a gas within the mixture.

With reference to the operations originated by Mr. Picard and myself about July, 1903, wherein a gas was liberated or generated in the pulp or air was blown in to float an oiled mineral, the apparatus used was of a laboratory type in all cases, that is to say, the vessels of various shapes were of glass, and the tubes and connections were of glass or rubber; cylinders, beakers, bottles, basins, placques, and so on. Several types of mixing were employed. In some cases the mineral was pre-oiled in agitation apparatus of the cone-Gabbett type; in other cases, by vigorous hand stirring or shaking in

bottles. In other cases the mineral was not pre-oiled, but the oil was blown in by air, sometimes aided by steam, either as
269 spray or as vapor. I remember that scent spray bottles were used and several arrangements of induction pipes for atomizing purposes. Our success in these operations was of a very imperfect nature, and our specification rather represented a pious hope that (241-166) we should ultimately attain success in these lines. The floats obtained were in general thin and tender, and were mainly of the nature of surface tension effects at the water surface. We tried a great many experiments on various lines indicated, but in no case were we able to attain to a persistent and coherent froth. After a considerable amount of time and experiments, we discontinued our efforts in this direction, owing to the small degree of success experienced and from the apparent improbability of such processes developing into a commercial method for mineral separation from gangue. The quantities used of oily matter were always substantial, that is to say, they would always be in excess of one per cent upon the ore taken. At that time we had no knowledge of the effective use of quantities of oil below the proportions employed by Cattermole, and regarded these Cattermole quantities as being likely to be required in flotation work of the nature we were experimenting upon.

Q. 48. Is the apparatus which you have described as being used in these experiments of substantially the nature shown in Figures 1 and 2 of the drawings of Sulman and Picard's U. S. patent 793,808, and are you the H. L. Sulman to whom that patent was granted?

270 A. I am the Henry L. Sulman, one of the grantees of this patent, and the apparatus shown in all three figures reproduces, diagrammatically, essential features in apparatus experimentally employed by us, although in none of the three cases are the diagrams shown exactly those of apparatus employed by us. The diagrams were prepared by us in consultation with our patent agent, and gave rather more precise expression to the types of experimental apparatus we had used in our laboratory. I may mention that our patent agent, Mr. Ballantyne, attended at our laboratory and saw (242-167) many of these experiments in order to aid us in the drawing of the diagrams referred to in this specification.

Q. 49. You have described an apparatus substantially like that shown in Figure 1 of the patent in suit, No. 835,120, as having been constructed and operated. Will you state whether you built any other apparatus, at a later date, for the purpose of operating the process of patent 835,120?

A. The apparatus shown in the diagram of the patent in suit closely represents that which we jointly designed, and which was built at Aldermanbury Avenue for the agitation-froth process. I gave expression to this joint design in a drawing of about May 3d, 1905 (witness produces Report dated May 3d, 1905, and drawing). This drawing confirms the description I gave of the plant in my answer to question 27. This apparatus was built, under our super-

vision, by Minerals Separation staff, at Aldermanbury
271 Avenue, and was subsequently modified in some details. I made the drawing produced myself. I, personally, built no other apparatus, but was cognizant of the modifications of the plant referred to. So far as my memory serves me, these modifications resulted in eliminating the aeration table for the treatment of the coarse sands, and I think it was not very long thereafter before the up-currents to the pointed boxes were dispensed with.

At the request of counsel for complainants, the Commissioner marks for identification the report and drawing produced by the witness as "Sulman and Picard Report, May 3, 1905" and "Sulman Drawing Accompanying Report May 3, 1905."

Further types of apparatus were built and operated. Apart from Figure 2 of the drawing of the patent in suit, (243—168) as to which I have not answered, my memory of the next type of plant following that illustrated in Figure 1 of the patent in suit and in my drawing accompanying report of May, 1905, is that it had a series of square wooden boxes for the agitation vessels, in place of the cylindrical glass vessels with baffles, which we had used hitherto.

The object of the classification of the gangue in the compound spitzlutte, shown in the drawing accompanying report of May 3, 1905, is set forth in that report, wherein it is indicated that by these means any coarse oiled mineral particles, not caught up and floated off with the froth, may be induced to sink in the first compartments of the spitzlutte, and freed from fine sands or slimes, with the idea that such oiled mineral might be recovered from the sunken
272 product by passing over the aeration table. At the date of our report of May 3d, 1905, we had not fully grasped how dense and coherent the agitation froths were, and having regard to the previous flotation experiences we anticipated that a considerable quantity of the coarser mineral particles would not be held in the froth, and that special steps would be required to deal with this. We shortly found thereafter that such precautions were practically unnecessary, and, as I have stated, they were subsequently discarded. Naturally, the proportion and size of the heavy mineral particles would be dependent on the mesh of crushing adopted for the particular ore submitted to such a method of separation as described in the patent in suit, and such a mesh was adopted in subsequent operations as would permit practically all the mineral particles being retained by the froth.

Q. 56. Was more than one apparatus constructed following substantially the drawing accompanying Report of May 3, 1905? (244—169)

A. Several sets of apparatus for continuous work, all closely following the essential principles of the drawing, were constructed, and small test apparatus was also designed by us for the experimental investigation of parcels of ore too small to be employed in the continuous apparatus, and for experimental work in connection with new ores.

Q. 57. As I understand the matter, the first apparatus following

the design shown in Sulman drawing accompanying Report
273 of May 3, 1905, was a small laboratory apparatus. After the construction of this first apparatus, was a comparatively large-size machine, built on the same general design, and if so, about what were the dimensions and capacity of such larger machine?

A. It is difficult to draw a hard-and-fast line between what is a laboratory apparatus and one of commercial or practical utility. The drawing in the patent in suit and the drawing by myself, before referred to, show glass agitation vessels combined with a spitzlutte apparatus which was 2 feet, 6 inches in length. This apparatus was capable of treating a very considerable quantity of ore, and if operated continuously would probably have been able to efficiently deal with perhaps half a ton of ore in twenty-four hours; possibly more. The next apparatus was built of considerably larger capacity, in which plant the glass vessels were replaced by wooden ones, and the capacity for ore treatment again greatly increased. I cannot from memory give the dimensions of this next type of apparatus. Several plants of this nature were built, from time to time, of varying and increasing capacity, details of which, after this lapse of time, I cannot carry in my own memory. There were square boxes for agitation purposes, retaining at (245—170) first the cone mixer, but afterwards the cone agitator of the Gabbet-type was replaced by cross-shaped agitators with four arms at right angles.

Speaking generally, the same high recoveries of mineral were obtained in the large, as in the small, apparatus. These appara-
274 tus followed the drawing of the patent in suit or my drawing of May, 1905, in all essentials, and in essentials all the plants built by Minerals Separation have followed the design given in the patent in suit, subject to such mechanical modifications as the practice of a process would naturally lead to on a large scale. A froth separation of the valuable mineral was always aimed at and substantially obtained. If film flotation was effected, that was an indication that the plant was not being operated to its purpose and best effect, and the plant operations were thereupon adjusted and regulated to give a coherent froth and not a film. Unless the running of the plant was in some way hindered or interfered with, such as by a temporary failure of the ore supply or at the beginning and end of the operation, no film flotation was permitted.

I have been continuously acting in a professional capacity for Minerals Separation, Limited, since the beginning of 1905, and I so acted, with about six months' interregnum, for a period before that time.

In the bottle test used by Minerals Separation, Limited, for ascertaining whether an ore is amenable to the process of the patent in suit, a weighed amount of powdered ore crushed to suitable fineness was mixed in a bottle with about four times its weight of water. Sulphuric acid was added until the pulp had definite acidity, such acidity being below one per cent of the pulp. The requisite quantity of oil, namely, a fraction of one per cent upon the ore, was then added by means of a pipette. Sufficient space (246—171)
275 was left in the bottle to include a substantial amount of air or free space above the pulp level. The contents of the bottle

were then warmed by immersion in a warm water bath until a temperature of about 40° Centigrade was reached. The bottle was then closed by a tightly fitting cork and the contents shaken for some minutes with considerable violence by hand. The agitation was stopped; when, on placing the bottle upright and keeping it stationary, a thick froth of mineral rose to the surface; when the sands that sank to the bottom of the vessel were visually deemed to be sufficiently depleted of mineral; and when the gangue slimes, still in suspension in the liquor, showed by their color or whiteness that the slimed mineral had also been removed into the froth. Different degrees and times of agitation would be necessary with different ores and with varying oils. The temperature might also be varied and the amount of acid necessary to produce sensible acidity would also vary with the nature of the ore constituents.

The removal of the froth from the bottle was not so easy a matter, quantitatively. It could be done to some extent by floating off the froth by addition of water through a funnel, but special types of apparatus were evolved by us to ensure a better collection of the froth.

Q. 95. What characteristic of the ore constituents would necessitate varying the amount of acid to produce sensible acidity?

A. Any substance present in the ore which would combine
276 with sulphuric acid, such as metallic or alkaline earth oxides, hydrates, carbonates, or in fact, any substance decomposed by highly dilute sulphuric acid.

Q. 96. In other words, if I understand you, in order (247—172) to produce the necessary sensible acidity it would be necessary to add enough acid to react with the substances you have mentioned in order that some free acid might remain; am I right?

A. Certainly, with acid of that dilution.

Q. 97. Do you remember who took up the question with your patent solicitors of making application for U. S. patent 835,120 in suit, whether yourself, Mr. Ballot, Mr. Picard, or whom?

A. I think we all three of us saw Mr. Ballantyne on the matter.

Q. 100. Were the seven instructions summarized in Sulman and Picard's Report of March 3d, 1905, conveyed to Mr. Higgins in writing?

A. Yes, in this manner: Mr. Ballot, Mr. Picard and I had several consultations shortly prior to this time and jointly determined upon the list of factors to be investigated. These were written out by myself in consultation, and in the presence of Mr. Ballot, and, I think, Mr. Picard, and were handed to Mr. Higgins either by myself or Mr. Ballot.

Q. 101. Can you produce these instructions which were given to Mr. Higgins?

A. No, I cannot.

Q. 102. Have you a copy of them?

A. No, I have no copy.

277 Q. 104. You are not sure whether Mr. Picard was present or not?

A. I know Mr. Picard was present at the consultation when the factors to be investigated were mutually agreed by all three of us.

I am not sure whether he was present when these were written out by myself. (248—172)

The froth formed according to the process of patent 835,120 in suit consists of an assemblage of bubbles of air, with some traces perhaps, of other gases, but mainly air, the bubbles being of various sizes from exceedingly minute ones to quite large bubbles. The surfaces of these bubbles are highly contaminated with slightly oiled mineral. The mineral particles are of all sizes from the finest slime mineral up to particles of sensible size, say up to sixty mesh, and sometimes even coarser. The slime mineral particles appear to be closely associated with each other and with the larger particles at times in the form of spongy flocks, the whole mineral being so intermixed, as regards its varying sized particles and flocks and with the air bubbles, as to form coherent froth of a somewhat spongy nature.

The nature of the froth varies somewhat with different minerals, but all have the same specific matter, coherent and persistent characters when the plant and process are operated to their best purpose and effect. The froth so obtained, when broken down by mechanical means, or by draining, results in a deposit of the mineral particles which exhibits to the touch and upon inspection no visible traces of oil, and one would not suspect the presence of oil unless
278 an analysis were made.

Application was made for a German patent upon the subject matter of the United States patent No. 835,120 in suit, and a German patent thereon was not granted.

In carrying out the process of the patent in suit, it is, of course, well that the operator should be informed as to the amount of ore which he is treating in order to maintain the proportions of oil and acid to ore, or should take such steps himself as would enable him to apply the agitation froth process described in suit under any abnormal conditions of feed. The adjustment of oil, even under (249—173) such abnormal conditions, is, however, very easily effected, because the phenomenon of the agitation froth production is in itself an indication of the right amount of oil to employ. If, therefore, it were not convenient to quantify the ore supply from time to time, it would be quite easy and effective to slightly vary the oil addition to the incoming pulps in order to produce the maximum agitation froth formation. This method of regulating the oil supply we might call a synthetic mode of regulation as compared with the more analytic method of adding known quantities of oil to a previous quantified ore supply.

Q. 120. Then, it might be, that an operator following what you have termed the synthetic mode of regulation might not
279 know whether he was adding oil or acid within the proportions set forth in the patent in suit?

A. It might be so, for the space of a minute or two; as to the acidity, this can be determined instantly by means of Litmus paper, or other suitable indicator, it only being necessary to have a slight degree of acidity present in the pulp. As to oil, the proportions specified in the patent do not need extremely fine adjustment. When the generally minute quantities of oil to ore are considered, which

amount in practice, roughly, to about two pounds per ton of ore in a great number of cases, or perhaps somewhat less or more, conditions of ore supply may fluctuate to some extent without greatly affecting the result. If these fluctuations in supply are excessive then the operator would naturally make such further slight adjustment of his oil addition as would meet the altered circumstances.

Q. 121. You have stated that the amount of oil used in this process approximates two pounds to a ton of ore. Can you make a similar approximation regarding the amount of acid? (250—174)

A. No. This will be determined for each particular ore and run of ore by experiment. Thus, ores which contain calcite will require more acid than ores which contain none, and rough approximation would be made experimentally upon an average sample of the particular ore in question. Thereafter, the rough quantity having been determined the pulp will be regulated as to a sufficiency of acid by Litmus paper or some such means.

280 Q. 122. I invite your attention to the drawing of United States patent 787,814 granted to J. D. Wolf on April 18, 1905, and inquire whether you ever used an agitating or mixing apparatus similar to that shown at the left hand of that drawing?

Counsel for complainants objected to the reference to this Wolf patent as incompetent for the reason that the patent is not set up in the answer.

A. Yes; I have seen the apparatus to which my attention is drawn and have seen it in operation at Mr. Wolf's works. It was used in connection with an oil buoyancy process where in thick viscous oils were used to entrap and buoy up mineral particles in the same general manner as the Elmore process. The object of this agitator was to disseminate the thick oil in globules of sensible size through the pulp in order to bring them into contact with and thus to entrap metallic particles in suspension in the water beneath the oil. The globules of oil then rose to the surface with any entrapped mineral by the buoyancy of the oil, and the mixed floating oil, with its entrapped mineral, and water, were then discharged into a pointed box wherein the separation of mineral and oil from sunk gangue was started. (251—175)

Q. 123. You have stated that if it were not convenient to quantify the ore supplied from time to time it would be quite easy and effective to slightly vary the oil additions to the incoming pulps in order to produce the maximum agitation froth formation. In operating according to this method the operator would be guided,

281 would he not, by the results secured rather than by the maintenance of any known quantitative relations between the different materials?

A. That is what I meant, the result to be obtained being the production of the specific agitation froth required.

After learning of the existence of the Froment British patent in August, 1903, I at once drew the attention of the gentlemen associated in Minerals Separation, Limited, to the abstract of the Fro-

ment patent published in the Journal of the Society of Chemical Industry in August, 1903.

Mr. Picard, Mr. Cattermole and I had already been working on these lines, but from the abstract referred to it was evident that in sundry particulars Froment had antedated us, and the gentlemen who were interested with us in our previous work and in the Cattermole process decided to acquire the Froment patent. The Froment patent rights are now owned by Minerals Separation, Limited.

Q. 127. What was the first occasion, Mr. Sulman, upon which you ever saw the valuable constituent of a mineral floating as a froth upon a freely flowing pulp or suspended upon the surface of the pulp in the form of bubbles?

A. My impression is that it was during the experimental investigation of the Cattermole process in my firm's laboratory. I can no doubt give you approximate dates by referring to some of my firm's reports on the Cattermole process. (252—176)

282 Q. 128. I do not care for the exact date, but I assume from your previous testimony that this occurrence was earlier than the year 1905.

A. Certainly. I think it would be between the end of 1902 and the middle of 1903. In this connection the float material noticed was in the shape of Cattermole granules now and again floated by surface tension effect to the top of the upcast separator instead of their normal sinking to the bottom of this separator. This occurrence was by no means a froth. My first memory of anything approaching to a mineral froth was towards the middle of 1903, when carbonic acid gas was chemically generated in a pulp containing mineral oiled in the Cattermole proportions.

The function of the baffles in the Gabbett apparatus was to give the agitation normal to the apparatus of which they form an integral part. Such baffles were invariably used during the first part of the Cattermole granulation where it was necessary to agitate the oil and the mineral to the extent required to uniformly coat the mineral particles with oil. The baffles were not used in the second portion of the Cattermole process where it was desirable to roll these oiled particles into granules. The use of baffles would have been inimical to the carrying out of the second stage of the Cattermole process, as in this stage the use of baffles would have prevented the building up of the shot-like granules in the Cattermole process, but the baffles assist the operation of the process of patent

283 835,120 in suit at all stages, inasmuch as the baffles produced the violent agitation and the entraining of air necessary to float mineral as a froth when quantities of oil were used insufficient for granulation. (253—177)

Q. 134. I assume from the explanation you have given that when a square vessel is used with an agitator provided with radiating arms, the non-circular character of the vessel and irregular form of the rotating body in a measure dispensed with the necessity of independent baffle members?

A. That is so.

In the second stage of the Cattermole process where the cone ro-

tates in a cylindrical vessel not provided with baffles, the liquid is given a mass rotation or rolling movement.

The bubbles forming the froth resulting from the process of the patent 835,120 in suit contain air and other gases in small quantity, though such other gases are not necessarily present. Such other gases are carbon dioxide and occasional traces of sulphuretted hydrogen, carbon dioxide being the more common.

Q. 140. I presume in treating ores containing a considerable amount of an easily decomposed carbonate there will be a larger amount of carbonic acid gas than in the treatment of ores containing less carbonates? Is that correct?

A. I do not think it necessarily follows to a substantial degree. The agitation operation requires a certain period before the oil is disseminated over the mineral particles and during this time
284 the carbonates, which were decomposable by the dilute acid employed, would have been decomposed and large quantities of air would have been beaten into and out of the mixing vessel before an opportunity were given for the froth to form. Very considerable proportions, I should think the major proportion, of the carbonic acid so generated would have been eliminated in the mixing (254—178) vessel. I state this fairly broadly, and I should expect to find rather more carbon dioxide in the froth derived from a mineral containing calcite than from one which did not contain calcite. I should not, however, regard the presence of carbon dioxide in the froth as an essential concomitant but rather as an accidental inclusion therein.

Q. 143. You have referred to the fact that you and Mr. Picard were developing or working upon a flotation process at the time you first learned of the existence of the Froment process. Is the process which you and Mr. Picard were then occupied upon, the one set forth in United States patent 793,808 granted to yourself and Mr. Picard July 4, 1905?

A. That is the only flotation patent that Mr. Picard and I worked at alone, but there was another flotation process about the same time in which we were also concerned with Mr. Cattermole, United States patent No. 788,247.

The Commissioner notes that copies of the several documents produced by the witness and marked for identification have been handed to defendant's counsel.

285 Cross-examination:

X Q. 144. Please state generally your experience as a metallurgist, including your education and your associations in that art.

A. I am past president of the Institution of Mining and Metallurgy and a fellow of the Institute of Chemistry, Great Britain. I am also a member of the Society of Chemical Industry and of several other technical societies. I received my chemical and metallurgical training at University College, London, where I devoted four years to the (255—179) study of these subjects. I was awarded the gold and silver medals for practical and theoretical chemistry, respect-

ively, and the bronze medal for fuel and metallurgy. Since leaving college in 1881 I have been engaged exclusively in the practice of the profession of technical chemistry and metallurgy and since about 1891 I have been exclusively engaged in metallurgical work. I have traveled in connection with my metallurgical work in South Africa, Australia, the Malay States, Japan, Canada and the continent of Europe. I have had considerable experience in the treatment of various ores, gold, silver, copper, lead, zinc, etc., and am well acquainted with the general processes used for extracting these metals from their ores. I am also conversant with methods of concentrating ores and have given particular attention, of late years, to the concentration of ores by means of oil.

X Q. 145. Exclusive of your inventive and investigating work for Minerals Separation, Limited, one of the complainants,
286 have you been consulted as a metallurgist and have you made inventions relating to metallurgical subjects? If so, please briefly outline this work.

A. I have. I am the co-inventor with Dr. F. L. Teed of the bromo-cyanide process, a modification of the cyanide process, which has been extensively used, and is still being used in Australia for the reduction of refractory gold ores. This process has already successfully treated about 5,000,000 tons of refractory telluride ores in Western Australia and other refractory ores elsewhere. I have also co-operated with Mr. Picard in developing and perfecting his invention for the reduction of refractory zinc-lead ores by what is known as the briquetting process. I am the inventor of a (256—180) process for treating refractory lead-zinc ores by a wet process with the aid of sulphurous acid. I also invented a method for converting the dry ball-mill into a wet crusher and this invention has been used by Messrs. Krupp of Germany for many years past.

X Q. 146. By what concerns have you been consulted as to oil concentration processes?

A. I have been consulted in relation to a float gold process, of which I was also the inventor, which was devised for the purpose of avoiding losses of gold as float material by a method of reducing the surface tension of the milling water, and also in regard to the precipitation and coagulation of slime material from milling water by means of a soap solution. This was in 1893 and 1894. I
287 have also been consulted by the inventors of the Robson and Crowder oil process, also by clients in regard to the Elmore oil process, who were investigating the latter, with the object of working it in a British colony. I have also been consulted with regard to the Cattermole, Froment and other processes which are antecedent to the patent in suit as to date, and I am generally cognizant with the details of other oil processes which have been invented of late years, including that of Wolf, by whom also I was consulted.

The mixing apparatus illustrated at the left-hand of the drawing of United States patent to Wolf, No. 787,814, and designated by the letter B, was a type of apparatus well known at the time of the application for the Wolf patent, May, 1903. Such apparatus was

built and sold by Messrs. Johnson of Stratford. It was designed to produce much the same effect as the apparatus generally known as a Gabbet or cone-mixer. The radial arms supporting the inner tube acted as efficient baffles, preventing the undue (257—181) rotation of the liquid mass as a whole.

The Gabbett or cone-mixer is an apparatus generally known to metallurgists by that name and is described in British Letters Patent No. 840 of 1889, granted to Haywood, Boulton and Gabbett. Such apparatus was well known to the industrial world and figures upon the covers of technical journals and had been known to me for many years previous to its application to the Cattermole process and was used by me in the laboratory for the aeration and
288 agitation of cyanide pulps.

I now produce a photograph of a plant for the operation of the Cattermole process, which was designed and erected and sent out to Australia. When this plant was sent to Australia, Mr. George Chapman went with it and to him a copy of this photograph was handed. Upon this photograph are red ink markings of a descriptive nature in my own handwriting. This plant consists of a battery of mixers, of which the vessels are formed of metal at the bottom and glass at the top. These mixers are arranged in three series and each is fitted with an internal revolving cone.

The Commissioner marked the photograph for identification as "Photograph Australian Cattermole Plant."

I now produce the reports of my firm relating to the plant which I have just described, dated November 19, 1903, and March 4, 1904. These reports are signed by my firm in my handwriting and were delivered to Mr. John Ballot.

The Commissioner marks the reports for identification as "Sulman & Picard Report November 19, 1903" and "Sulman & Picard Report March 4, 1894," and copies of these reports are handed to defendant's counsel. (258—182)

X Q. 156. In the work done by you for Mr. Ballot and those associated with him, first in the Cattermole Ore Concentration, Syndicate, Ltd., and afterwards in Minerals Separation, Lim-
289 ited, what was your habit as to making a record of the work done for these concerns?

A. No matter how closely we collaborated and how intimately all the experiments were known to those concerned, Mr. Ballot always insisted upon such results being put into complete form as a record of work done, and this was always carried out by us.

X Q. 157. Please produce reports of this nature other than those you have heretofore produced, describing them by the respective dates of the reports.

A. I now do so, and describe the reports as dated 25th March, 1903; May 5th, 1903; September 24th, 1903; April 19th, 1904; May 2nd, 1904; May 18th, 1904; 17th February, 1905; 21st February, 1905.

The several documents are marked by the Commissioner for identification, each as "Sulman & Picard Report," followed by the date appearing on such report.

Mr. Picard and I devised several types of small scale-testing apparatus for separating the froth after it had been formed, but we found the best method was to cut the froth portion of the pulp from the gangue portion by means of sliding the top portion of the vessel away from the bottom portion upon a suitably constructed slide device. The first type of such apparatus consisted of a block of wood divided longitudinally into three cuts, the bottom portion forming the bottom of a series of vessels which were formed by boring a large hole through the two upper parts. This rough apparatus operated so well that we devised a glass (259—183)
290 and metal agitation vessel for performing the same action with accuracy and efficiency. Two or three of such apparatus were constructed by Mr. Picard, and I now produce the first of these which fulfilled all the necessary requirements. This apparatus was described by us in a report to Mr. John Ballot, dated February 24, 1910, which I now produce. This apparatus was shown by us to Theodore J. Hoover.

The Commissioner marks for identification the apparatus as "Sulman & Picard Slide Machine" and the report as "Sulman & Picard Report, February 24, 1910."

This particular apparatus was made some little while before the date of this report, February 24, 1910, and had been tested by us, but others of the same type had been previously made and experimented with and it was not until we got the results that this improved type gave us that we reported the matter to Mr. Ballot.

I am not prepared to say that an agitation froth could not be produced in a Gabbett from which the baffles had been removed.

Each of the reports produced by me is dated on the day that it was written and it was immediately delivered to Mr. Ballot.

By film flotation, which is also referred to by us as skin flotation, is meant the flotation of particles of oiled or unoiled mineral at a water surface by surface tension effect. Such films would contain the mineral particles in a layer, not substantially exceeding one particle thick. Both oiled and unoiled mineral particles
291 form such films, but the films of oiled mineral are much more persistent than films which are composed of unoiled particles. Such films may occasionally contain isolated bubbles coated (260—184) with, or contaminated by, such mineral particles, but such occasional bubbles would not form a froth.

The phenomenon of agitation froth flotation involved physical reactions, which may be broadly classed under surface tension phenomena, but not in the sense in which I had employed that term in defining film flotation. I have devoted considerable time to studying and experimenting in an investigation of the scientific aspect of flotation phenomena, and I have found that the effect of heat in the specific phenomena of agitation froth flotation is advantageous

to the operation of agitation froth production in two main respects. The first of these, and perhaps the lesser effect, is the decrease of viscosity of the oil with increased temperature by which it is capable of more ready subdivision and dissemination throughout the mineralized pulp. The second effect of increased temperature is the modification of surface tension effect between the water and oiled mineral surface in the direction of a beneficial effect in the attachment of air thereto.

X Q. 171. What have you found to be the effect of mildly acidifying the water of the pulp in the specific phenomena of agitation froth flotation?

A. Acidified water tends to wet the gangue particles more
292 efficiently than plain water, or water unacidified, and thus prevents the adhesion of oil to such particles to a greater extent than obtained when unacidified water is used.

X Q. 172. Is this a chemical or a physical phenomenon?

A. It is entirely a physical phenomenon.

Relative to the Elmore and Wolf processes, both of these processes were bulk oil processes, which depended upon the buoyancy of the oil for supporting the mineral entrapped (261—185) in it. Considerable viscosity of the oil was necessary to prevent the heavy mineral from sinking out of the oily mass too rapidly when so entrapped. The Wolf process involved the use of oil made still more viscous by the use of chloride of sulphur. In both these processes increased temperature led at once to decrease in viscosity and considerably enhanced the tendency of the entrapped mineral to fall out of the bulk of oil in which it had been entrapped.

In the Wolf and Elmore bulk oil processes, if agitation exceeded a certain moderate limit, the oil became emulsified in the pulp and a mass of heterogeneous material was formed in which oil, water, mineral and gangue were contained as a "mush." Such of this material might float, whilst other portions would sink; no separation of mineral from gangue would be effected, and with violent agitation the whole mass would form an emulsified product which might be likened to a salad dressing of the mayonnaise variety, but containing ore.

293 The stationary baffle marked *a'* shown in Figure 2 of the patent in suit would act and did act efficiently as a baffle.

X Q. 177. In your answer to Q. 108, you speak of well-known types of apparatus to ensure uniformity of condition as to pulp supply. What well-known types of apparatus did you refer to?

A. I referred to the many known types of slime settlers and pulp thickeners which are extensively used for the purpose of dewatering and settling fine ore suspensions for the purpose of obtaining a uniform thickened ore product.

X Q. 178. What, in your opinion, is the best means of determining that the agitation froth process of the patent (262—186) in suit is being carried on in a large scale plant?

A. The efficient production or realization of the specific phenomenon of the agitation froth.

X Q. 179. In Q. 97 you were asked who took up the question with

your patent solicitors of making application for the United States patent in suit. I now ask you the same question as to the making of the application for British patent No. 783 of 1905, filed April 12th, 1905, a copy of which I now show you.

A. I remember that Mr. Ballot, Mr. Picard and myself took up this question with our patent solicitor, with whom we jointly had many interviews. Mr. Ballantyne, a member of the firm of our patent solicitors, attended for this purpose both at our laboratory, at the Works laboratory at Aldermanbury Avenue, and
294 at Mr. Ballot's office on several occasions.

Redirect examination:

R. D. Q. 182. Whenever flotation concentration takes place in a pulp to which too little oil to float the mineral by the oil buoyancy has been added, and the pulp has been agitated with the result of raising all of the oiled mineral to the surface as a scum or froth, would you assume that air, beaten in by the agitation, has caused or assisted the flotation?

A. This is a very wide question, and would apparently include all quantities of oil below the effective bulk oil limits down to the proportions of oil used in the patent in suit. All sorts of phenomena would take place according to the amount of oil employed and degree of agitation given. Some oil entrapping mineral with entangled air bubbles might result, and in such cases the air would aid oil buoyancy (263—187) effects, just as corks caught in a fishing net might enable the latter to float. According to the extent or deficiency of oil, intermediate phenomena would take place, such as the production of "mushes" or of sunken material, but to the extent that oiled material was floated, entangled air bubbles would naturally help to this extent.

R. D. Q. 183. Assuming that flotation concentration has taken place in a pulp to which an amount of oil, equal to two per cent by weight of the ore, has been added, and the pulp has been agitated, thus producing the flotation, would it be your opinion that air beaten in by the agitation had caused or materially assisted,
295 in producing such flotation?

A. My experience of such conditions as you have named, and with the degree of agitation that I have been accustomed to give, is that granulation would mainly result, and it is not my experience that effective flotation would ensue if the pulp were then brought to rest.

I am the consulting metallurgist of Minerals Separation, Limited, with Mr. Picard, and am engaged in investigating and researching upon the various scientific points which arise in connection with this, and similar processes, and also in answering or helping in such metallurgical questions as may arise in any connection with the processes from time to time.

Recross-examination:

Considering the specification of the patent in suit, without any reference to the apparatus described or shown in the drawings, in

my opinion a metallurgist would be fully informed at, say, th early part of the year 1905, by such description of the process, e clusive of apparatus, to carry out the agitation froth process d scribed in the patent. (264—188)

Testimony for Defendant of Hugh Fitzalis Kirkpatrick-Picard.

LONDON, ENGLAND, August 9, 10, 1912.

Direct examination:

I am 41 years of age, a resident of London, and by profession consulting metallurgist and assayer, and am one of the grantees o patent 835,120 in suit.

296 I first learned of the use of oil or fatty matter as a mean of separating part of the constituents of an ore by flotation about the year 1898. I here refer to my knowledge of the Elmor buoyancy process. I first learned of the joint action of oil and gas to produce flotation as an accidental concomitant during our work on the granulation Cattermole process about 1902, wherein some of the granules were occasionally, accidentally, floated by air. I first learned of the intentional use of oil and a gas to produce flotation of the constituents of an ore early in 1903, some few months prior to our first learning of the Froment process. The intentional use of oil and gas is to some extent set forth and described in United States patent 793,808, granted to Henry L. Sulman and myself, July 4, 1905, on an application filed October 5, 1903. After learning of the Froment process, I experimented with that process.

Q. 8. Will you describe your trial of that process, your mode of procedure and results?

A. A sample of crushed ore was taken and mixed with a small amount of powdered carbonate of lime, to this was added water, and on the top of the charge a thin layer of oil was placed. The vessel in which the mixture was, was then agitated so as to thoroughly mix the oil with the crushed ore. After the mixing was judged to be complete, (265—189) a quantity of mineral acid was added to the charge and the whole contents of the vessel gently stirred, the effect being that the bubbles of carbonic acid gas gen-

297 erated by the mineral acid on the carbonate attached themselves to the oiled particles of mineral, which, more or less completely, rose to the surface of the liquor, leaving the depleted residue at the bottom of the bottle or containing vessel.

Q. 9. In the patent in suit, No. 835,120, in an example of the application of the process the amount of oleic acid used in that instance is specified as from .02 to .5 per cent on the weight of ore, the latter quantity being twenty-five times the former. How would an operator practicing the process determine between these wide limits what quantity of oil to use?

A. As a matter of fact, both quantities mentioned are so minute in relation to the proportion of ore that it is hardly right to describe the limits as very wide, but the operator would have no diffi-

ulty in determining, if there was any marked difference, which was he best quantity to use, by simply noting whether he was obtaining he specific frothing phenomenon which the patent indicates as eing that required.

Q. 10. In other words, the ordinary skill of the operator would ead him to the right amount, as I understand it?

A. Yes, I think an operator after studying this specification, nd possessing average technical knowledge would have no difficulty n so adjusting the amount as to obtain this specific and very defiite form of froth.

Q. 11. Did you ever try the Froment process proceeding, as irected by Froment in his British patent 12,788 of 1902? (266—190)

298 A. Yes, certainly. The only information we had at first was from reading Froment's patent, and our tests were conequently based upon the information contained in the document.

Q. 12. I invite your attention to the passage extending from line 3, beginning with the words, "such for example," to the end of he paragraph, which begins with those words on page 2, and ask whether you ever tried Froment as there directed.

A. I have no doubt that as our experiments were conducted from ur reading the specification, that a test of this kind, if not exactly f these quantities, was made. I cannot definitely remember whether xactly these quantities were used in any specific test.

Q. 13. Do you remember the result secured when operating acording to Froment's patent referred to?

A. I remember generally that fairly good recoveries of the sulphide minerals were obtained, but I have no figures of any particular test, showing actual recoveries.

Q. 14. When you say that the recoveries were fairly good, do ou mean that they were as good as when you operated as stated n your answer to question 8?

A. Yes.

Q. 15. When these trials of the Froment process, referred to in our answer to question 8, were carried out according to Froment's irections in the patent referred to, did you work with Mr. Sulman?

A. Yes, we were working constantly together on these matters.

299 The first demonstration which I witnessed of the process of patent 835,120 in suit was conducted by Mr. A. Howard Higgins, one of the works staff of Minerals Separation, Limted, in March, 1905. Mr. Higgins was at (267—191) that time ngaged under instructions from Mr. Sulman, Mr. Ballot and myelf, in investigating, amongst other things, the influence of the uantity of oil on Cattermole granulation, and it was as a result f repeatedly reducing the quantity of oil that eventually we arved at the production of the specific, permanent and coherent roth which is referred to in the patent in suit.

Q. 19. These various factors affecting the Cattermole process had een under investigation for quite a long period, had they not?

A. Investigation was always going on, but this particular investi-

gation was originated by Mr. Sulman, Mr. Ballot and myself, not very long prior to the time that this discovery was made. We did issue a report which gives the list of investigations to be made and the date of that report will indicate how long the investigations were proceeding before we made this actual discovery.

Q. 20. Were you present when what you call the discovery was made?

A. I was not in the works at the actual moment when the first froth was produced, but I certainly saw it within an hour or two of its production. I believe Mr. Ballot, one of the patentees, was present at the moment of its production, and it was Mr. Ballot, who, after seeing it, sent for me and Mr. Sulman to inspect it.

300 Q. 21. Where were you and Mr. Ballot and Mr. Sulman when you gave these instructions to Mr. Higgins regarding the subjects to be investigated regarding the Cattermole process?

A. We three were meeting every day for discussions on these matters, and I think the specific instructions referred to were come to at a meeting of us three at our (268-192) office, 44 London Wall, but I cannot be quite certain that they were not arrived at at a meeting at Mr. Ballot's office. I clearly, however, remember the meeting and the discussion which led to adopting the programme of work to be done.

The instructions given to Mr. Higgins to investigate the various factors of the Cattermole process were given to him some weeks before the discovery was made, and certainly within the year 1903.

Investigation has constantly been going on during the developing stages of the Cattermole process, and Mr. Higgins, after he had been trained by us in oil work, took part in these investigations.

Q. 26. Is it your impression that at the time of this meeting between yourself, Mr. Ballot and Mr. Sulman, it was a new idea to investigate how much oil, acid and what character of agitation should be used in the Cattermole process?

A. My general recollection is that we had been for sometime working, more or less in the dark, without understanding the influence of the various factors of the process, and we decided that it would be well to adopt some form of definite line of research,

301 with a view, if possible, of clearing up various points of difficulty in connection with the work.

Q. 27. Do you mean to convey the idea that prior to the meeting between yourself, Mr. Sulman and Mr. Ballot, to which meeting you have referred, the experimentation by the staff of Minerals Separation, including Mr. Higgins, had been more or less desultory and unsystematic, and that you decided to have them systematize their operations?

A. I certainly do not accuse the staff of Minerals Separation of carrying out their work in a desultory manner, (269-193) because if I did I would be equally accusing myself, who was largely responsible for the work. In developing an entirely new process such as this, one must necessarily for a time come across factors, the meaning of which are not clear, and in the early stages much of the work must necessarily be of the trial and error description, and

to that extent I am prepared to admit a certain amount of desultoriness.

Q. 28. I notice from the documents of your firm and of Minerals Separation, Ltd., which have been shown to us during this proceeding, that the Cattermole process was not a new idea as early as March, 1903, and I see from these reports that experimentation for the purpose of perfecting this Cattermole process was active from a date at least as early as March, 1903, down to the year 1905; that during that period, and during the early part thereof, the various factors of the process were altered in the various experiments.

302 Now, what I want to have you tell us is just what difference was brought about in this experimental work by the instructions which you say were given jointly by Mr. Ballot, Mr. Sulman and yourself to Mr. Higgins, or to other members of the staff?

A. I find that question somewhat difficult to answer. During the earlier stages we had been experimenting largely on different types of plant, on different ores, and it was only after a great deal of that work had been done that the plant appeared to have become somewhat established and systematized, and starting on that assumption it was decided to more systematically than hitherto attack the problem of the influence of these factors in our then fairly well established type of apparatus. (270-194)

Q. 29. The effect of these instructions, then, as I understand it, was not so much to change the character of the work as to make it more systematic; am I right in this?

A. I do not quite understand what you mean by the character of the work.

Q. 30. By the character of the work I mean the nature of the investigations, such as endeavoring to ascertain the most advantageous quantities of acid, oil, possibly dilution of the pulp, character of agitation, temperature and such other factors as would naturally appeal to an operator of the process as being important. With this explanation can you answer the question?

A. I think I can only answer your question by saying

303 that the object of the investigation embodied in the instructions was to give a better knowledge of the working of our process than we had before and thereby to give us more control over it.

Q. 31. Work for the attainment of that purpose stated as generally as you state it, had been going, had it not, for over two years prior to the instructions given by yourself, Mr. Sulman and Mr. Ballot?

A. I thought I had dealt with that in a previous answer. True, work of an investigating character had always been going on, but in the early stages we were a much longer way off finally, so far as conducting the operations were concerned, as we had settled on the final type of plant, and probably also on the best oils to use. It was only, after much of this, what I have described as trial and error work, was done, that one could hope to systematize the work in a more definite manner than had been possible hitherto.

When I first saw the process of the patent in suit (271-195) per-

formed, it was performed in an ordinary Gabbett or cone mixing vessel, fitted with usual baffles, such as are employed for the usual Cattermole process. This apparatus was not at that time so arranged as to operate continuously. It is desirable to perform such a process continuously. As a commercial proposition, it is, of course, always desirable to make any metallurgical process continuous if possible, though intermittent processes may be quite commercial in their results, but this process lends itself very readily to continuity.

304 The next step after the demonstration I have referred to was building and fitting a spitzkasten arrangement to receive the agitated material. Thereafter several plants of various sizes were built, but I cannot now recall the different plants and locate them accurately at the different works occupied by Minerals Separation, as from the early summer of 1906, when I went abroad, not in connection with this business, I had very little to do with the practical development of the process.

The first machine built and operated, after the first demonstration of the process, contained Gabbett or cone mixers in series and the last of the series discharged through a turned up pipe and delivered the material on to a short launder, whence it was conveyed to a series of spitz boxes. These spitz boxes were in the first instance provided with upward water currents, but the use of these upward water currents was soon abandoned. Satisfactory concentrates were obtained, which were floated off the end of the last spitz box of the series as a thick, coherent, persistent froth. The concentrates were not obtained in any other form than the thick coherent froth when the plant was working normally and properly. (272-196)

X Q. 48. During the period from 1903 to 1906, when you were in touch with this work, I understand that quite a number of different apparatuses, large and small, relatively, were constructed for the purpose of carrying out this process. What was the purpose

305 of building this succession of different apparatuses?

A. To arrive at that most suitable to carry out the desired object.

Q. 49. Is it your recollection that the latter machines were more suitable for that purpose than those first formed, that is, the first formed with spitz boxes?

A. Yes, later ones were certainly better in various detail particulars than earlier ones.

Q. 50. In what particulars did the later machines differ from the earlier ones?

A. One difference lay in the adoption of wooden mixing vessels, which was advantageous on the ground of economy. Other alterations consisted in the mechanical details of driving the shafts of the mixing vessels, which in the earlier machines were frequently badly damaged, and another alteration adopted in the latent types was replacing the cone Gabbett agitator by a blade form of agitator. I have no doubt that other detail developments took place, but those are the ones which strike me most. I remember also that there was a different arrangement of the spitzkasten part of the plant. I have recollection of one plant in which two or three spitz boxes were

placed underneath each other instead of all being in one tier, and another alteration that I remember was placing the spitzkasten close up to the delivery of the last mixer instead of conducting the pulp through a shore launder. That, I think, generally indicates
306 the changes that were made in the (273-197) various plants.

Q. 52. During this period of development you are aware of no reason for introducing any change in the first apparatus which you saw, other than the simple desire to make the apparatus more compact, or to simply adapt it to the shape of the space where it was to be placed, or something of that kind?

A. I cannot recall any particular reason except for improvements in mechanical details. I may say that the process, in my opinion, worked perfectly in the first plant, and therefore, except for mechanical reasons, I can recall nothing which might be held to be an essential alteration in the working of the process.

In working the Cattermole granulation process we found that some of the mineral in the form of granules tended to float, though the great bulk of the mineral was recovered in the form of sunken granules. The small amount of floating mineral obtained in this process was a source of trouble to us.

Q. 67. Will you state the distinction between the froth or scum which is referred to in the patent in suit, and the floating material resulting from operations such as described in United States patent 793,808, granted to yourself and Mr. Sulman on July 4th, 1905, as the result of an application filed October 5, 1903?

A. I have already described the froth produced in the patent in suit as being of a very dense, coherent and thick deposit.
307 The floating concentrate obtained in patent 793,808, on the other hand, was of a very feeble and tender character, the very reverse of coherent and persistent, and was of such a nature that extreme care had to be used in its collection. It never reached any appreciable thickness, (274-198) and was rather of the nature of a thin film.

Q. 68. To what do you attribute the difference between the condition of the floating material produced in accordance with the process of the patent 793,808, and that produced under the process which patent 835,120 purports to disclose?

A. I attribute the difference largely to the greater quantity of oil that was used in working the patent 793,808. The oiled mineral produced under this patent was more of the Cattermole variety, and in our experience air introduced in the manner shown in Figure 1 does not attach itself very readily to these particles of mineral heavily oiled, and though the air did, to a large extent, carry the mineral flocks to the surface, they, the flocks, seemed to sink again with ease in such a manner as to suggest that the air which caused them to float had freed itself from the particles.

Q. 69. Was an apparatus such as shown in Figure 1 of patent 793,808 built and operated?

A. Yes, something very similar to this. I do not recall an apparatus similar to Figure 2, but I have a definite recollection of something of the nature of Figure 3 having been tried.

Q. 70. I take it, then, that you attribute the defective
308 action which you have referred to in the operation of the apparatus of Figure 1 of 793,808, to the use of too much oil?

A. Yes, I think that in large measure accounted for the relative non-success of this process, but on the other hand, I do not think success would have been obtained with this particular apparatus, even though the quantity of oil had been much reduced. (275-199)

Q. 71. From which I infer that it is your idea that the success of a froth flotation process of this kind is dependent, not only upon the use of the proper quantity of oil, but also upon the use of mechanism adapted to bring about othre conditions equally necessary to the production of a froth?

A. Of course suitable apparatus must be employed to carry out the object set forth in the patent specification, and we show one method by which these objects may be obtained, but no doubt other forms of appliance would effectively carry out the intention of the patent which is essentially the production of the dense persistent and coherent froth which is the peculiar attribute and essential feature of this invention.

Q. 73. You have referred to the froth produced by the process which the patent in suit purports to set forth as dense, coherent and thick. Does that process in practice result in producing a froth which is distinguished from other froths which you have seen produced in these characteristics of density, coherency and thickness?

A. According to my experience, the characteristics of
309 this froth are essentially different from any other kind of mineral froth that I have seen produced.

Q. 74. Are these characteristics so essentially different that observation of a froth enables you to state whether it has been produced by the process which patent 835,120 purports to set forth, or by some other process?

A. I do not think I should have any difficulty in distinguishing between the froth obtained by the patent in suit and that produced by any other means known to me.

Q. 75. Could you distinguish, by observation, that is, by visual observation, between froths produced by the use (276—200) of five-tenths of one per cent, one per cent, one and a half per cent and two per cent, respectively, of oil?

A. I should have no difficulty, I think, in distinguishing the five-tenths per cent froth from the two per cent, and probably from the one and a half per cent, but I do not know what is the absolute limit in quantity which would render it difficult for me to distinguish between them. I may state that by using the upper limit of two per cent in the apparatus described in the patent in suit I should expect to find an appreciable quantity of granules formed, and this would aid me in forming an opinion as to the amount of oil used.

Mr. A. Howard Higgins entered the employ of Sulman and Picard in December, 1903, and in June, 1904, he joined the Minerals Separation staff.

310 In actual practice the same apparatus was employed for the process of patent 835,120 in suit and for the Cattermole process, but in the process of patent 835,120 in suit it is more essential to beat in air, which is not an important point, and rather to be avoided, in the Cattermole process, where the object was only to mix the various ingredients, air not being one of them.

Referring to the apparatus and process of patent No. 835,120 in suit, I should say that the froth was present, so to speak, potentially in the pipe H, that is to say, if the Gabbett agitator were stopped, froth would at once rise to the surface of the liquid in the Gabbett.

In my opinion the invention of patent 835,120 in suit was complete after the first operation thereof.

Q. 79. You have referred to having been called in to witness the operation of forming a froth according to the process which the patent in suit purports to set forth (277—201) shortly after the discovery of such a mode of procedure was made. Will you state just what you saw on this occasion that was new to you; that is, what was it you regarded as a discovery.

A. What struck me as being new was seeing practically the whole of the mineral which was in the ore charge floating on the top of the liquid in the Gabbett whilst at rest, whereas hitherto when using larger quantities of oil I should expect, and, indeed, would have seen, the mineral in a more or less granulated condition through
311 the charge, and not floating on the surface, except as to certain accidental flocks. The difference was most marked, and created a very distinct and decided impression on my mind.

Q. 80. I presume that you and your associates proceeded to investigate the causes which had produced this result, and, if so, what were the causes to which you attributed it?

A. We already knew from the first test that the cause was due to reducing the quantity of oil much below that hitherto employed, and observation of the froth clearly indicated that the air which had been beaten in played an important and essential part in the production of this new phenomenon. I presume that further investigation work was carried on, but in my opinion, the invention may be said to have been complete after that first operation.

Q. 81. At the time the process which the patent in suit purports to set forth was first exhibited to you, I take it that you were not then for the first time made cognizant of the possibiliy of using so small a quantity of oil as had been used, or that you then first became cognizant of the utility of beating air into the pulp; am I right in this? (278—202)

A. I had no idea prior to this, that by reducing the quantity of oil to the limits which were used in this expediment that such a result would be obtained. I, of course, knew that air would float mineral, previously oiled, but it was not anticipated by me thitherto that this particular result would be obtained if air were beaten in, in the manner in which it was done in making this test. The result
312 of the operation as a whole was an entire revelation to me, and though I knew that work was being carried out on the re-

duction of the quantity of oil, I never for one moment anticipated in my mind, as being likely to occur, what in fact actually did occur.

Cross-examination:

X Q. 82. In Q. 11, you were asked if you ever tried the Froment process as directed by Froment in his British patent 12,778 of 1902, and in Q. 12 your attention was called to a particular passage in the Froment specification, commencing on line 33 of page 2, and you were asked whether you ever tried the Froment process as there directed. Please explain fully your answers to those two questions, supplementing what you have already said by anything further which may be necessary to make your meaning clear.

A. Perhaps the only point that wants elaborating is the order in which I added the various ingredients. I made a large number of tests, and it is possible that in some of them the order may have varied from that which I gave in answer to question 8. What I did was to take the specification and exercise my knowledge of these matters to the best advantage, so as to obtain the best results that the process was capable of. It was therefore my usual practice to add the acid after the other ingredients, as I wished to get the oil well mixed with the ore before (279—203) destroying the carbonate of lime present, which was necessary to produce carbonic acid gas for the separation of the oiled mineral. That I was right in this
313 procedure is clear, because at a subsequent date Messrs. Minerals Separation received instructions from Froment on how to work his process, and in these instructions he advised the performance of the operation on exactly the lines followed in my experiments. This is clear, not only from written instructions, but also from a drawing which was supplied, in which the mixing without acid is shown in one vessel, and the separation by the addition of acid in a second vessel.

X Q. 83. Can you, and will you, produce Froment's description to which you have referred, and also his drawings, to which you have referred?

A. This is the description, and these are the drawings.

The commissioner notes that the witness produces a document in French, entitled "Description et Instructions pour la Concentration des Minerals" and a large and small sheet of drawings, and at the request of counsel for complainants marks the description for identification as "Froment Description" and the large drawing as "Froment Drawing" and the small drawing as "Froment Drawing A."

Froment sent a small sized plant to Minerals Separation, Limited, to be used in carrying out his process, but I never used this apparatus because I was satisfied that only indifferent results could be obtained by its use. Furthermore, the apparatus was of too large a size for use in our laboratory and it was eventually sent to the works of Minerals Separation, Limited. A search has been made for
314 the (280—204) apparatus, but it has not been found and I think it has been destroyed.

Redirect examination:

R. D. Q. 85. Do you remember whether you carried out the process of the Froment patent before you received the instructions and drawings from Mr. Froment, to which you have referred?

A. Yes, certainly, many tests were made before we received the drawings and instructions. (281—205).

Testimony for Defendant of John Ballot.

LONDON, ENGLAND, August 12–17, 1912.

Direct examination:

I am 52 years of age, a resident of London, and chairman and managing director of Minerals Separation, Limited, and chairman of Minerals Separation American Syndicate, Limited, the two complainants.

The defendant, Mr. Hyde, was employed by Minerals Separation, Limited, to carry out the work of a syndicate formed to investigate in Mexico. The members of this syndicate were Messrs. Lazard Bros. & Co., London; Messrs. Beer, Sondheimer & Co., Frankfort; and Minerals Separation, Limited, London.

Immediately after Mr. Hyde's arrival in London, Mr. T. J. Hoover, who was then our consulting engineer, which practically means that he was the chief engineer of the company, was requested by me to give Mr. Hyde every possible instruction and all information necessary to enable him to acquire the necessary knowledge to equip him for the purpose of the duties which he was destined to undertake and had undertaken to carry out in the Republic of Mexico. I may here mention that I understood from both Mr. Hoover and Mr. Hyde that they had known one another for years, and Mr. Hoover assured me that Mr. Hyde was a fully qualified engineer, to whom the business could be safely entrusted. Mr. Hoover, on my instructions, placed at Mr. Hyde's disposal, all the files of patents in our office relating to the Minerals Separation processes, not only the patent in suit, but everything on file at the time. Mr. Hoover also placed at Mr. Hyde's disposal his own reports and notes (282—296) on the process made during his visit to Australia, as well as comments and notes relating to the patents and processes. After spending some days or probably weeks, I do not know how long, in mastering these details, he was taken to our test works, then at Charlotte street, off Great Eastern street, where he was shown various apparatus, both small scale and large testing plant in use and operation at that time. I personally had discussion with Mr. Hyde before he left for Mexico and asked him whether he had gained all the information that he thought necessary to enable him to carry out the work which he had undertaken, and he gave me his assurance to the effect that he had. I would here mention that before Mr. Hyde arrived in London a special type of machine had been invented or designed by Messrs. Sulman & Picard,

known as the slide machine. Messrs. Sulman & Picard com-
316 municated the information to Mr. Hoover; Mr. Hoover discussed it with me, and at my request took the matter up to have similar machines built for use in our Charlotte street works. The details of this invention were communicated to Mr. Hyde by Mr. Hoover, and our works manager, Mr. A. C. Howard, together with Mr. Hyde, were entrusted with the building of this by suitable makers. So soon as this machine was built one was placed at the disposal of Mr. Hyde, and he was given one of our works operators or experimenters, together to run through a series of tests as quickly as possible to get the handling of the machine and generally to become efficient in the management of it, as it was found to be a very efficient apparatus that would just suit the operations of the testing work with which Mr. Hyde was to be entrusted during the Mexican and other investigations for the purpose of (283—207) acquiring business for the syndicate. With this machine and with another one subsequently sent to him, Mr. Hyde carried out his tests, not only in Mexico, but also in Canada, where he was requested to go, and did go, early in November of 1910.

Q. 7. What is the source of your information to the effect that Mr. Hoover placed at Mr. Hyde's disposal all the files of patents in your office?

A. First, I requested him to do so; secondly, he assured me that he had done so; thirdly, because I saw Mr. Hyde reading them myself.

Q. 8. Does the preceding answer as to your source of information apply also to Mr. Hoover's reports and notes on the process
317 made during Mr. Hoover's visit to Australia, and his notes relating to the patents and processes?

A. My recollection is yes, with this qualification that when I make use of the word "process" I refer to the patent in suit, which was being applied and worked on a commercial scale, and which, of course, we wished Mr. Hyde to introduce into Mexico.

Q. 9. What was the nature of these reports and notes made by Mr. Hoover during his visit to Australia and his notes relating to the patents and processes?

A. To give a clear answer I should require to refresh my memory by reference to the documents. In general, the notes on his visit to Australia were on the working of the apparatus and the process there in practice. With regard to the patents and processes he had drawn up a memo of their sequence and their various characteristics. (284—208)

The London works of Minerals Separation, Limited, were purely testing and investigation works. The plant in Wales was erected for the special purpose of producing concentrates from a shipment of several hundred tons of San Francisco del Oro ore, which that company had sent to England to test out a process of zinc smelting, and this Welsh plant was erected at the works of a small smelter company in Wales with that object, and it produced a tonnage of concentrates from the San Francisco ore for their smelting tests.

Q. 15. What was your purpose in directing Mr. Hoover
318 to instruct Mr. Hyde as to the practice of this process, and to put in his hands his notes regarding the Australian practice?

A. To give Mr. Hyde as much information as possible of work on a practical scale, as no work on a commercial scale was being done in England, with the exception of the tests in Wales, and that plant also Mr. Hyde was specially requested to visit to gain as much information as he could.

Early in 1904, probably in March, Minerals Separation, Limited, sent Mr. George A. Chapman to Australia with a plant designed to carry out the process of the Cattermole patents which are referred to in the patent in suit; Mr. Chapman erected and operated that plant. During the early part of 1905, a hundred ton plant of the Cattermole type was built at the Sulphide Corporation works in Australia and completed and started operation about May, 1905. This plant was operated for a short period, but in the meantime the process of the patent in suit had been discovered and information regarding it sent to Mr. C. F. Courtney, consulting engineer for Minerals Separation, Limited, in (285—209) Australia, at that time. I wrote Mr. Courtney March 3, 1905, as follows:

"And also to hand you copies of Messrs. Sulman & Picard's report of the third inst., together with Mr. Higgins of 2d inst. with two sheets of curves to show the very important results obtained. As the
319 various reports and curves will explain themselves I have but little to add, and I trust that you will be pleased with the result."

I quote the following from a letter written by me to Mr. Courtney March 10, 1905:

"I am pleased to tell you that during the week we have made some very important discoveries which will, I think, almost revolutionize our processes by way of simplifying and cheapening the same. I hope that by next mail the work will be sufficiently far advanced to send you full particulars. Several points have yet to be determined, and the discoveries are of such a nature that we have decided to take our expert and counsel's opinion thereon with a view to assuring ourselves that we can get good protection under patents. I may mention for your private information that we do not use more than .1 per cent of oleic acid per ton of ore and although we have not assays out that the recoveries will be very satisfactory."

I also quote the following from a letter written by me to Mr. Courtney written March 17, 1905:

"Higgins Report. Herewith I enclose you copy of Higgins report as received this morning, being a continuation of the one sent you on the 3d March. By using one per cent. of acid water or even less than that, three of water to one of ore, and adding .1 per cent of oleic acid, and heating the circuit to from 30/32 C. and then agitating
320 from 8 to 10 minutes in a single gabbet we find that almost as soon as the cone is stopped in the Gabbett from 70 to 80 per cent of the contained mineral immediately rises to the surface in the form of a scum or froth which floats persistently and remains on the surface of the water for days at a time. Any heavy mineral that may be present and not carried up with the froth is readily sepa-

rated from the coarse sands by ordinary tabling. This experiment has been repeated again and again. The ore treated was ground to 60 mesh originally but we found that only a very small percentage remained even on 90 mesh, the bulk passing through 150. I think this discovery very important indeed and have no doubt that you will thoroughly test it on your straight ores as well as on your tailings and old slimes, especially the stack of rich slimes on the mine, as it will merely need agitation and running off into settling (286—210) tanks with some mechanical device for skimming off the floated froth or perhaps a large nest of conical upcasts or spitzkasten may be made to do the work and I have no doubt that you will soon solve the mechanical problem for fixing up suitable apparatus.

"As I wrote you in my last, we are having our patents thoroughly overhauled in view of these developments, and it will therefore be necessary to keep this as confidential as possible until we know the result. Even with 30 mesh stock Higgins finds that although
321 not much flotation takes place as only the slime mineral rises to the surface, the coarse mineral is still sufficiently oiled to permit a perfect separation by tabling with air-blast by air-distributor. This factor is important as it reduces the consumption of oleic acid to a vanishing point, being only .1 per cent. per ton of ore treated and that can be very readily washed off the concentrates with a weak alkaline solution for the purpose of separation or breaking down. In the case of copper ore or ores not requiring separation, I take it that it will hardly pay to recover the oleic acid."

The reports of Sulman & Picard of March 3, 1905, and of Mr. Higgins of March 2 and March 16, are the reports thus dated and heretofore marked for identification.

Q. 19. What was the purpose of having your patents thoroughly overhauled, as set forth in your letter of March 17th, 1905?

A. I think just a business precaution.

Q. 20. Why is it that you cautioned Mr. Courtney to keep the information contained in your letter of March 17th, 1905, confidential until you knew the result of the overhauling of your patents?

A. So far as my memory serves me the object of doing so was because at that time Australia was not under the Patent Convention, and if any information had leaked out before we had lodged a patent there somebody else might have pirated the idea.

Q. 21. What did this have to do with the overhauling of
322 the patents which you already had? (287—211)

A. It is an expensive matter to take out patents, and we did not wish to take out patents needlessly if the discovery had already been protected by any of our previous patents.

Q. 29. I take it that when Mr. Higgins apprised you of the operations set forth in his report of March 16th, 1905, this was not the first occasion upon which you had been informed of the possibility of using minute quantities of oil in mineral flotation operation; am I correct in this?

A. I had seen the work in progress from about the 1st day of March onwards.

Q. 30. When you saw Mr. Higgins' operations about the 1st of

March, 1905, that was not the first occasion, was it, upon which you had been informed of the possibility of using minute quantities of oil in mineral flotation processes; by minute, I mean quantities within the range set forth in the patent in suit?

A. No, I had never seen it before within the range of the patent in suit.

Q. 31. You kept in close touch, did you not, with the operations of the technical staff of Minerals Separation, Ltd., including the operations of Messrs. Sulman & Picard?

A. Yes, I did.

Q. 32. That is, you kept fully informed as to the investigations conducted by Messrs. Sulman and Picard and by the staff of Minerals Separation, Ltd.?

323 A. Yes, as fully as I possibly could.

I consulted with Messrs. Sulman & Picard, especially in the earlier years, almost daily, frequently several times a day, and watched operations carried on in their (288—212) laboratory, and later on Aldermanbury Avenue and the other laboratories that we had. But in later years, of course my work had accumulated so much that I had to leave it to other members of the staff, so that I could not pay the frequent daily visits which I was accustomed to pay, perhaps until October, 1906, when Mr. T. J. Hoover arrived and took up his duties as general manager.

Q. 34. And when you saw the work in progress from March 1, 1905, onwards, as referred to by you in your answer to Q. 29, was this the first occasion upon which you had been informed as to the use in an oil flotation process of the intentional beating in of air for the purpose of promoting flotation?

A. The intentional beating in of air to produce or promote the flotation of froth which was developed by that process was certainly not known until the fact had been actually discovered that by using a very small quantity of oil, say, .2 or .1 per cent, and agitating it for a certain time, and then leaving the mixture stand that the whole froth rose to the surface. By "discovered" I mean until the experiments had established the fact that this extraordinary phenomenon was every time reproduced by using the small quantity of oil, violently agitated, and then leaving it to stand, when the

324 mineral rose to the surface in the form of dense froth.

Q. 35. I understand from your last answer that you mean that a discovery was made about March 1st, 1905, and that subsequently the operation was repeated simply to verify the result secured; is this the distinction which you mean to draw between the word "discovered" and the word "established"? (289—213)

A. The discovery was made about, or soon after, March 1st. And as soon as we had experiments repeated to show that the same phenomenon was constantly reproduced we considered it established and that the principal cause of flotation, or perhaps the entire cause of flotation, was due to air beaten into the pulp, assisted, of course, by the other agents, oil or oleic acid and sulphuric acid.

Q. 36. What was the result of the thorough overhauling of your patents referred to by you in your letter of March 17, 1905, to Mr. Courtney?

A. The results were that our patent attorneys very strongly advised us to protect the froth discovery under a patent.

Mr. A. Howard Higgins was an associate of the Royal School of Mines.

Q. 41. In answer to Q. 37 you mention sulphuric acid as one of the substances included in the term "other agents" appearing in your answer to Q. 35. In what manner does sulphuric acid contribute to the flotation effect?

A. I believe it keeps the oil from going to the gangue. It
325 also had an effect of settling slime gangue more readily, and by keeping the oil from sticking to the gangue, naturally it assists the mineral in picking up the very minute traces of oil disseminated throughout the mass of agitated pulp.

Q. 42. The patent in suit gives a range of quantity for the oleic acid to be used extending from .02 to .5 per cent in the example set forth in the paragraph beginning at line 70, page 1, the larger quantity being twenty-five times the magnitude of the smaller. In carrying out this process how is the determination to be made as to which of these widely differing quantities is to be used? (290—214)

A. Starting with the small quantity, say at the rate of one pound per ton of ore, an operator can soon tell by the appearance as to whether the characteristic froth is produced or not. Guided by appearances he would either increase or decrease the quantity of oil or oleic acid until the cauliflower or characteristic froth was produced, which in itself will be an unfailing index as to whether or not proper conditions have been attained, and he need only then repeat the measurements quantitatively of oil or oleic acid added to his pulp. Of course I assume that the proper agitation and other factors are satisfactory.

Q. 43. I understand from your answer that the way to carry out the process which the patent purports to set forth, is to operate with varying quantities of oil until what you term the "characteristic froth" appears, and then to keep on operating with the proper
326 portion of oil ascertained to have been used in producing such a characteristic froth as you have referred to; am I right in this?

A. In small scale tests the operator would naturally quantify or measure the quantities of oil added, whether they be above one pound per ton or below one pound per ton, and would judge by the appearance of the froth and result when the best proportion had been hit upon.

Q. 44. Would you make a distinction as to the mode of operation upon a commercial scale?

A. On a commercial scale, or before commercial operations are begun, small scale work should, and would invariably, be carried out to determine the best quantities, and the oil supply fed to a commercial plant would be calibrated accordingly, that is, after ascertaining the quantity of ore plus water fed into the plant, the oil feeding apparatus would be set to deliver as nearly as possible the
(291—215) quantities per ton determined by small scale experiments.

Q. 45. In your answer to Q. 42 and the following question, I understand that the quantity of oil must be determined experimentally, and that the proper amount of oil is determined by noting the quantity which produces the froth, which you state has certain characteristic qualities. I understand, then, that it is impossible to carry out the process by simply applying the proportions of oil set forth in the patent, and that the final test is not the use of any particular proportion of oil, but the production of the froth; is this correct?

A. The only way to carry out the process is that of applying the proportions of oil set forth in the patent, but to determine, as all practical men will do, which of the proportions, within the range, yield the best result, the characteristice nature of the froth is always an indicator which will of itself tell an experienced operator when the best conditions have been attained, or having been attained, whether they are maintained in a continuous running, where variations may occur in the feed to the plant of ore and water or pulp.

Mr. A. Howard Higgins was sent to Australia by Minerals Separation, Limited, and was there from the Summer of 1908 to the spring of 1909. The slide machine to which I have referred was not necessary for the purposes of the process of the patent 835,120 in suit, but it was a very convenient form of apparatus.

Q. 51. Before the slide machine was designed by Mr. Sulman or Messrs. Sulman and Picard, as the case may be, did you have other mechanism for making tests of that kind?

A. Yes, we had several, the principal was the ordinary Gabbett, by which the process was practically originally (292—216) discovered, which consists of a single mixing vessel, with a cone agitator and loose baffles slipped over the sides. The agitator was driven either by a small motor direct coupled to the agitator shaft, or by a belt, and the agitation took place, and after a sufficient amount of agitation had been given to it the cone agitator was stopped, and as soon as the contained pulp and water came to a rest the froth always floated to the surface. After leaving for some minutes, the gangue settled out and the concentrates were either skimmed off by spooning or they were flowed off by inserting a funnel through the froth some distance into the water below and pouring in more water, so that the Gabbett was filled and the froth permitted to flow over the rim of the Gabbett, when the products were collected and assayed. The tailings, that is to say, the residues, were drawn off either by pouring off the water or by emptying the residue through an opening in the bottom of the mixing vessel, when a similar operation was repeated, if necessary, and as often as was necessary.

Q. 62. Were the apparatus and methods in use at the London testing plant at the time of Mr. Hyde's engagement by the Mexican Syndicate the same as those described and illustrated in the patent in suit?

A. Broadly, yes. In small scale apparatus there was the modification of the slide machine, also an apparatus attempting to carry

out the frothing test on a small scale by drawing off the froth c
tinuously. The larger scale plant was modified to the extent
having three or four single spitz boxes connected with the squ
agitation vessel by means of a tube some three or four inches
diameter passing from agitator-box to frothing-box, the tailings bei
lifted from the frothing-box by means of a (293—21
329 pneumatic pump, that is, a pump operated by means of
under pressure, into the second agitating vessel, and fr
there onwards the operation was repeated in the same way, the fr
from the first and each spitz box overflowing into a launder wh
carried the total contents to a collecting box or filter bed as the c
may be.

Q. 66. Did the small scale apparatus and the larger scale pl
referred to in your answer to Q. 62 operate in substantially the sa
way?

A. Substantially, yes, the same characteristic froth was produc
but the chief difference consisted in the one being a continuous pl
and the other intermittent.

Q. 70. I would like to have you, Mr. Ballot, if you will, descr
the mechanism and arrangement of this small scale machine wh
was designed for the continuous drawing off of the froth.

A. This special small scale apparatus, as referred to as I und
stand the question, consisted of one square box with glass sid
The agitator was suspended from the top by means of a shaft a
had instead of a cone a simple cross made of two crossed blades
metal which formed the beater or agitator. The shaft was driv
either by a small motor coupled direct to it or by pulleys. T
spitzkast was outside with a small rubber tube connection from n
the bottom of the agitation-box to the spitzkast, feeding in part
the way down or over the little apron or launder as the case may
I would here say that I am not sure whether at one time
330 another this particular apparatus did not consist of
spitz boxes worked side by side with a tube or pipe con
tion from the one to the other, the agitated pulp being fed into
spitz at the end of the second box as before described. (294—2

Q. 71. In carrying out the process which the patent in suit p
ports to disclose, what decree of agitation did you give to the o
and acidified pulp?

A. So far as my memory serves me, various agitators were
volved at different speeds according to their size and the size of
vessel in which they were used, but I think that in practice genera
a speed varying from one thousand to sixteen hundred, and so
times more, peripheral feet per minute is usually found to be
efficient degree of agitation.

Q. 72. How did the degree of agitation imparted to the pulp
the practice of the operations set forth in the patent in suit comp
with that used in practicing the Cattermole process which is refer
to in the patent in suit?

A. In the Cattermole process, if I remember rightly, there w
two degrees of agitation. In the first series of mixers the agita
was fairly violent to disseminate the oil throughout the pulp an

t the mineral particles. In the second portion of the process a
y much slower rolling motion was given to enable the mineral
rticles to attach themselves to one another and to be rolled into
all shot-like granules.
In the practice of the patent 835,120 in suit, if an oil-like oleic
acid were to be thickened or solidified by cold, it would nat-
31 urally be necessary to warm it up to liquefy it.
All of the ores and tailings operated upon by Minerals Sepa-
tion, Limited, in Australia, contain calcite, some very little and
hers a good deal more. The calcite and fluorite contained in the
n Francisco del Oro ore caused a very heavy consumption of acid.
295—219)
Q. 78. During your investigation, that is, the investigations of
inerals Separation, Limited, into the Cattermole process, during
e two years or more preceding the year 1905, I presume the Catter-
ole process was operated under varying conditions as to degree of
itation, amount of acid, oil, dilution of pulp and so forth for the
rpose of ascertaining the value of that process. Am I correct in
is?
A. That was so.
One of our staff is at present engaged in the erection of a Minerals
paration plant at the Cuba Copper Co.'s mines in Cuba.
I first learned of the Froment process some time in August, 1903,
om a publication of an abstract of the Froment patent specifica-
n.
Q. 90. When did you first learn of the use of oil or fatty matter
a means of producing the flotation of part of the constituents of
ore suspended in water?
A. The action of an oil was first known to me almost in my school-
y days in so far as it relates to the greased needle effect. The acci-
dental flotation of small portions of granulated mineral I
2 think first appeared during the Cattermole investigations.
The flotation of oiled mineral by means of gas chemically
nerated and liberated in a pulp first became known to me by the
ttermole, Sulman & Picard flotation process and the Sulman &
card process or discovery taken out by them before Froment's
tent was published. I have not included the oil buoyancy process
Elmore, which I have studied during 1901 and 1902, as being
ferred to in this question.
Q. 91. Did you ever see a froth produced upon a pulp containing
re than 1 per cent oil, that is, the amount (296—220) of oil
ual to more than 1 per cent of the ore?
A. I have seen the gas bubble froth effect as produced by the Fro-
nt type or the Sulman & Picard's bubble type of process, caused
liberating a gas in the pulp, but I have never seen a froth of the
aracter produced by the patent in suit, with that quantity of oil.

(Here the witness described the details of apparatus used at the
cessive London laboratories of Minerals Separation, Limited.)

Q. 105. I will read to you a question that was put to you as a
ness, and your answer thereto, in a suit in the King's Bench

Division in the High Court of Justice, this suit having been brough
by the Ore Concentration Company, Limited, against Webster an
others, including yourself, and ask you whether in that suit you di
in fact answer such a question in the words which I now read t
you? The question and answer are as follows:

333 "1062. Just tell his Lordship why your name is men
tioned in some of these patents, the first one is, I think—i
I am wrong correct me—an application of the 13th January, 1903
1821 of 1905. The applicants are Sulman, Picard and Ballot. The
you come into some others. How was it your name comes into thos
patents?

"First, because I was chairman of the Minerals Separation, an
when these inventions were made I was specially directed by th
directors of Minerals Separation to have my name added to it as
matter of extra protection for the company.

"1063. You yourself taking an interest in the development o
these patents? I took a very considerable interest in it, closely watch
ing the better part and watching everything that was going on.

"1064. You mean the experiments? In the experiments, an
naturally suggested anything, everything that I could think of."

A. Yes.

The suit in the British courts above referred to concerned the titl
to certain patents owned by Minerals Separation, Limited, th
British patent containing the subject matter of United States paten
835,120 involved (297—221) in the suit at bar, being one of thos
patents so owned by Minerals Separation, Limited.

Q. 110. From your testimony above quoted I understand that i
some cases your name has appeared as a grantee of Britis
334 patents in cases where you were not the inventor of the sub
ject matter thereof, as I understand is permissible under th
British law. Am I correct in this?

A. As a matter of fact I do not believe that my name has appear
in any cases in the invention of which I did not participate.

Q. 111. The reason which you give in your testimony quote
above why your name appears upon the patents therein referred
is that you were chairman of Minerals Separation and were special
directed by the directors to have your name added as a matter o
extra protection for the company. That would be sufficient reaso
in itself, would it not?

A. That was not the reason why my name appeared in the paten
in suit or the corresponding British patent. What I stated to th
Court at that time was perfectly true, that the board of the compan
thought it advisable for me to have my name added to patent
but our patent agents advised differently, as is evidenced also by
number of patents owned by our company on which my name di
not appear.

Q. 113. What part did you have in th[illegible] invention of the proce
claimed in United States patent 835,479 and the correspondin
British patent?

A. It is impossible to tell you what particular part I had in the i
vention as Messrs. Sulman, Picard and myself collaborated and co

sulted daily and between the three of us we undoubtedly evolved the process and the apparatus (298—222)

Q. 114. Do you remember with whom the idea of using
335 gas pressure as set forth in the claims of this patent, originated?

A. No, I do not remember. It was the product of our joint conferences or consultations.

Q. 115. Do you remember that you had any part personally in originating the idea of using gas pressure?

A. It is impossible to differentiate the part I had in it from any part by Sulman and Picard.

I first saw a demonstration of the process of patent 835,120 in suit some time between the third and tenth of March, 1905, while Mr. A. Howard Higgins was carrying out the program of work set him by Sulman, Picard and myself, and especially while he was step by step reducing the percentage of oil in the experiments. On this occasion Mr. Higgins and myself were present. I was present because I was closely interested not only in the special program of work set Mr. Higgins by Sulman, Picard and myself, but in all research or experimental work being carried out, and I made it a daily practice of visiting the test works at Aldermanbury Avenue, sometimes more than once a day, and I also as often as possible visited Sulman and Picard in their own laboratory, where they were carrying out investigations, and I was naturally anxious to see the developments of the experiments or tests carried out by Mr. Higgins, especially so because, during the earlier part of his experiments, when he had reached the limits of about .5 or .6 per cent, considerably
336 more mineral float appeared on the surface, which rather puzzled us.

The Froment description and drawings were received by Minerals Separation about December, 1903, certainly as early as December 30, 1903. (299—223)

Q. 125. Will you state, if you can remember, what kind of an apparatus Mr. Higgins was using in his work at the time he was reducing the amount of oil, as you have stated?

A. He used what we generally describe as a single Gabbett, which consisted of a cylindrical vessel with a hemispherical bottom set in a brass mounting. The agitation was performed by means of a cone mounted on a shaft, suspended into the Gabbett and driven either by a small motor, coupled direct to the shaft, or by a belt and pulley, and over the sides of the mixing vessel four movable baffles were adjusted so as to reach down on the inside of the mixing vessel well into the pulp contents of the charge. These baffles just described were at will removed or reintroduced in the course of the operation, as the operator desired. (300—224)

Cross-examination:

Relative to the program of work set for Mr. Higgins by Messrs. Sulman, Picard and myself, this program was prepared by us in writing and was handed to Mr. Higgins by Mr. Sulman in my presence.

While Mr. Hyde was absent in Mexico, the United States and Canada, he was continually informed of how to test certain
337 ores and what particular oils to use in experimenting with the same. In short, he was kept fully informed of everything that we thought it necessary or expedient that he should know or be informed upon. On his return to London we placed at his disposal all Mr. Nutter's reports on the Australian plant and position, as well as a particular document dealing with the future development or technical development of Minerals Separation process dated 3d December, 1910, which document I now produce. He was also shown our new works at King John's court with all the plant as then at work including the froth-trap apparatus which was specially designed to produce a high recovery but a low grade concentrate, the object and intention being to retreat these low grade concentrates by flotation in the ordinary way, and in general I discussed with Mr. Hyde even such confidential matters as the appointments of agents in the United States and requested him to give me his opinion, which he did in writing. I also requested Mr. Hyde to bring up a memorandum as the result of his investigations and experience on the North American position with a view to carrying on an active campaign in the countries included, under his own supervision as one of several technical engineers we had in view for the purpose. I now produce this document dated the 8th January, 1911, and signed by Mr. James M. Hyde. (301—225)

At the request of counsel for the complainants the Com-
338 missioner marks for identification the two documents produced by the witness as "Nutter Report, December 3, 1910," and "Hyde Report, January 8, 1911."

X Q. 131. When Mr. Hyde was sent to Mexico with testing machines of the slide type, as you have testified, were any instructions given to him as to these machines, with a special regard to publicity of their exhibition and use?

A. He was requested by me to keep the machine as confidential as possible and even if need be to get a special room in which to carry on his tests privately. The machine itself had not been patented by us and we naturally did not wish too much information to be given to the public on that account. I would add that when he left our service he was requested to immediately return the machine to our custody or to that of our agents. This I believe was done in course of time.

I received an apparatus from Froment and have made a search for this apparatus, but could not find it and fear that it has been scrapped. The apparatus received from Froment consisted of a round or cylindrical mixing vessel, mounted on three or four legs. It was built of sheet iron and as a mixer it was fitted with an arrangement consisting of two beaters made of stout wire, somewhat like gridirons, but so arranged that, while revolving in opposite directions, the wires freely passed between one another. I can perhaps better illustrate it by referring to a common form of egg-beater.

These agitators were driven by suitable gear, and the mixing
339 vessel was fitted with a discharge tap. The next part of the apparatus consisted of a circular tank. (302—226) Into this was fitted a coil of lead pipe, with one end projecting above the rim of the vessel. The coil itself was placed near the bottom and the pipe was perforated with small holes. In addition to this there was fitted to this tank an apparatus resembling a rake, which was fixed to a vertical spindle. This spindle was mounted from bearings over the tank, and, if I remember rightly, had a handle fixed to the upper end, with which to revolve it in operating the plant. The third part of the apparatus consisted of a rectangular wooden tank or box, into which was fitted, just about the water level, a sheet of perforated aluminum, which was connected with a mechanical device overhanging the tank, in such a way that it could be freely rocked or shaken by means of a series of impacts. The gear giving the impacts was arranged outside, to be driven by hand.

X Q. 135. What was the final outcome, and what in general the proceedings in the suit referred to in Q. 105, and a few succeeding questions?

A. There were two trials and one appeal. At the second trial the plaintiffs, through their counsel, withdrew their allegation and publicly apologized, and the suit was discontinued.

Redirect examination:

R. D. Q. 127. What is the source of your information or belief that the document identified as "Nutter Report, December 3, 1910," was placed at the disposal of or seen by Mr. Hyde, the de-
340 fendant?

A. I instructed Mr. Nutter early in 1911 to supply Mr. Hyde with a copy. Mr. Nutter informed me that he had only one copy left of his own, but he would pass that on to Mr. Hyde. Mr. Hyde himself soon after informed me that (303—227) he had received it from Nutter and had carefully studied it.

R. X Q. 142. Did you have any discussions with Mr. Hyde while he was in your employ as to the metallurgical situation in Butte, Montana. If so, please state their substance.

A. I had, early in January, 1911. You will notice that Mr. Hyde in his report of January 8, 1911, referred to Butte, Montana, in two places. The reason why I had a discussion with him about that was that during the latter part of 1910 Mr. Kuehn called on Mr. T. J. Hoover in his room at Minerals Separation offices. Mr. Hoover came to my room and asked me to come into his office, where he introduced Mr. Kuehn to me, and then mentioned that Mr. Kuehn had reported to him that there was a big mine at Butte, Montana, having a large body of zinc ore. We then both discussed it with Mr. Kuehn, and if I remember rightly, Mr. Kuehn told us that this had been a copper mine, but it had turned into a zinc mine lower down; at any rate, we thanked him for the information, and asked him to give us further particulars if he could do so, so that the existence of Butte and Superior was well known to Mr. T. J. Hoover

and myself at the time. Hence I discussed it with Mr. Hyde,
341 believing that he would be the engineer shortly to be entrusted with the development of our business in North America. I would refer also to the letter written to Mr. Hyde about November 23, 1910, while he was still in America, and marked for identification "Letter Minerals Separation to Hyde, November 23, 1910."

The Froment British patent was purchased on behalf of Minerals Separation, Ltd., in October or November, 1903.

The Commissioner notes that the witness produces a document and the same is marked for identification "Assignment Froment to Ballot, 17th November, 1903." (304—228)

This assignment was made to me for and in behalf of the group of individuals who had acquired the Cattermole patents and also some Sulman and Picard patents, and this Froment patent and all others referred to were taken over by Minerals Separation, Limited, as soon as that company was formed.

R. D. Q. 147. Were any tests made of the Froment process before the Froment patents were purchased by you on behalf of the parties you refer to?

A. Tests were naturally made by Sulman & Picard which led them to discover their own independent invention during July, 1903, and before the existence even of the Froment patents was known, and as soon as publication of Froment's patent took place, tests were carried out in small scale apparatus, according to that specification, that is, according to the directions given by
342 the patentee.

I personally negotiated the purchase of Mr. Froment's patents with him in Italy, at Milan, as set forth in the assignment of his patents, and while there I naturally asked Mr. Froment to give me all possible information and also I asked him to send us plans and drawings, together with clear and definite instructions, as well as to have a model plant built and shipped to England, for the purpose of carrying out his process as he recommended it should be done. This he promised to do, with the result that towards the end of the year the plans and instructions were received, and some time early in 1904 the plant itself was received in London.

In the early part of August, 1903, Minerals Separation, Ltd., sent a Mr. Freymuth to Italy to negotiate with Mr. Fro- ent, but Freymuth failed to effect the purchase of the Froment patent and we then directed our patent agents in London to open negotiations with Mr. Froment through Froment's (305—229) patent agent, Mr. Zanardo of Rome, and Mr. Zanardo secured an option which led to my going to Milan to meet Froment by appointment. (306—230)

Testimony for Defendant of Herbert Clark Hoover.

LONDON, ENGLAND, August 16, 1912.

Direct examination:

I am 37 years of age, by occupation a Mining Engineer, and a resident of London, England. I have been acquainted
343 with the defendant, Hyde, about sixteen or seventeen years. I engaged Hyde as an Engineer in February, 1911, both Hyde and myself being at that time in London. I asked Hyde to accompany me to New York to assist me in some mining business in Alaska and elsewhere. Upon arriving in New York I investigated some business in connection with the Butte & Superior Copper Company of Butte, Montana, and, in anticipation of sharing in the refinancing of that Company, I sent Mr. Hyde with Mr. Kuehn to Butte to examine and report on the Butte & Superior Mine. I told Mr. Hyde to try all of the various flotation methods on Butte and Superior ore and to report the results from those or any other metallurgical method that might suggest itself.

While in London previous to going to New York I had communicated to Mr. Hyde all of the information and experience I had in connection with flotation methods other than those of Minerals Separation, Limited, that is, the methods of De Bavay, Potter, Delprat and Elmore. I also placed before Mr. Hyde the whole of the inquiry I had made into the Everson method. I was left out of the financial end of the Butte & Superior Copper Company business and, therefore, told Hyde I was no longer interested and he could do as he liked in connection with that business.

I have been for many years Managing Director of the Zinc Corporation, which Company has used flotation processes on a large
344 scale. I have also been largely interested in the Amalgamated Zinc Company, which company used flotation (307—231) methods, and at one time I was interested in both the Potter Company and Minerals Separation, Limited.

In 1905 I first went to Broken Hill, Australia, and purchased large quantities of zinciferous tailings, which were ultimately transferred to the Zinc Corporation. At that time there were three flotation methods being exploited at Broken Hill and I visited all of the plants. The Potter flotation process was installed by the Zinc Corporation, the De Bavay method and Cattermole being the other two processes in use at Broken Hill. The Potter method proved a commercial failure at the Zinc Corporation. In the winter of 1907 the mill was altered for the apparatus of the process in use by Minerals Separation, Ltd. The alterations were designed by the engineers of Minerals Separation, Ltd., and the plant installed under their direction. This plant also proved a failure and after exhaustive trials the Elmore flotation process was adopted and found successful by the Zinc Corporation and this process was used until some time in 1910. During a considerable portion of this period, my brother, Theodore J. Hoover, had been acting as General Manager of Minerals Separation, Ltd., and he urged me to resume the

Minerals Separation, Ltd.'s process, stating that he had made such alterations in the Minerals Separation, Ltd.'s method that it was superior to the Elmore process. We made trials of the modified plant of Minerals Separation, Ltd., and ultimately discarded
345 the Elmore process and readopted Minerals Separation Ltd.'s, process. The Elmore process was the process sometimes called the Elmore vacuum process.

The concentrate was recovered as a scum or froth through some form of spitzkasten in the Potter, Delprat, Elmore and Minerals Separation processes. (308—232)

Cross-examination:

The Zinc Corporation are paying Minerals Separation, Ltd., two shillings and sixpence per ton upon an annual production of roughly, 90,000 tons of concentrates.

With the vacuum process we treated the coarse material which was at the same time the high-grade material, and we had with the Elmore process exhausted a large proportion of our coarse material. On the other hand, the Minerals Separation process has treated the finer material more satisfactorily, but I would not add that this material was unprofitable by the Elmore method. Perhaps I had better say that it was not so profitable.

X Q. 17. In the Minerals Separation process as now carried on by the Zinc Corporation, what re-agents are used?

A. Sulphuric acid and oil.

X Q. 18. And, as I understand it, the mineral pulp is vigorously agitated with sulphuric acid and oil, and flows into the spitzkasten, upon the surface of which appears a mineral-bearing froth, which is separated as the concentrate?

A. It does.

X Q 19. At the time when Zinc Corporation first adopted
346 a Minerals Separation process the process adopted was also one which would be describable by the language of my last question; this is true, is it not?

A. That is true in general lines.

As an incident accompanying the change from the first Minerals Separation plant to the Elmore vacuum process, the Zinc Corporation were compelled to raise more capital to reorganize the business again.

The improvements made by my brother, Theodore J. Hoover, in the Minerals Separation procedure were largely in the (309—233) direction of the mechanical devices in which the process was carried on. I do not pretend to have any great technical knowledge in the matter of these processes. My interest has always been on the commercial side.

Of the engineers of Minerals Separation under whose direction the first Minerals Separation plant was installed at the Zinc Corporation, Mr. Chapman was the principal gentleman with whom I came in contact.

When the first Minerals Separation plant was discarded, £140,000 sterling were expended in erecting the Elmore vacuum plant which

superseded the first Minerals Separation plant, and which in turn was superseded by the second Minerals Separation plant now in use, at an expense of £30,000 sterling.

Relative to the first installation of Minerals Separation plant, according to the Minerals Separation engineers when they designed
the plant, the ore-crushing facilities used in connection with
347 the plant were adequate. I recollect that subsequently the
head tonnage was greatly reduced below the anticipated capacity in order to determine if this was the difficulty, and our engineers advised us that it was not.

XQ. 33. It is true also, is it not, that on one occasion, when Mr. Chapman was present the plant was run under your direction up to 500 tons per day capacity, with the result that the mineral was not properly treated?

A. It is true that the plant was run at its anticipated capacity and proved wholly a failure at such a tonnage. The tonnage was subsequently greatly reduced without better results, from a commercial point of view.

The large accumulation of tailings at Broken Hill, Australia, resulted from the fact that over a period of many years the Broken Hill mines were unable to profitably extract the zinc and there had accumulated some ten to twelve million tons of mill residues, containing the major portion of the original zinc content. The use of the Potter, Delprat, Elmore and Cattermole and other methods, together (310-234) with the improvements which have been made in all these processes has enabled the accumulated zinc to be turned to profitable account, and the mechanical development of the long known flotation principle has largely contributed to the prosperity of the district.

I understand that I am testifying voluntarily, and I testify
348 entirely with the view to clear the charge which has been
leveled at Mr. Hyde that he entered upon connection with the Butte & Superior Company as a result of information obtained while in the employ of Minerals Separation, Ltd., which charge is untrue and wicked.

I have not assisted the defendant in the defense of this suit otherwise than appearing here as a witness. I do not know enough about the technical matters involved, nor do I have any desire to take sides in the main issues of this litigation. I have no interest directly or indirectly in Mr. Hyde's patent, No. 1,022,085. Mr. Hyde offered to present me with an interest in his invention, but I told him that I would not accept an interest in any process, even as a gift.

X Q. 52. I have what purports to be Directors' Report and Statement of Accounts for the period ending 31st December, 1911, of the Zinc Corporation, Limited, containing what is entitled "Directors' Report," and which appears to have been signed Mr. F. A. Govett and yourself as managing directors, and referring to an appended report of Mr. Theodore J. Hoover, and I find in this appended report the following statement, referring to work done with the vacuum machines stated to have been set aside:

"And that while the material treated by the former method was

very amenable to that method, it was a selection of material of the simplest metallurgical character amongst the Company's holdings, and that the remaining material was of such a character that
349 it could not have been treated profitably by the former process." (311—235)

Is the statement which I have quoted true or not?

A. The statement is no doubt true, but possibly a little overdrawn, as the sense intended was probably that the balance of the material could not be treated at nearly so great a profit. (312—236)

Testimony for Defendant of Arthur Howard Higgins.

LONDON, ENGLAND, August 17-19, 1912.

Direct examination:

I am 31 years of age, a resident of London, England, a metallurgist by occupation, and an Associate of the Royal School of Mines.

Q. 2. When did you first become engaged in research relative to oil flotation processes?

A. In December, 1903.

Q. 3. At that time, I believe, you were occupied with the Cattermole process, in which the object is to separate the oiled particles by permitting them to settle or be precipitated?

A. Yes, and also with the Froment process.

My investigations of the Cattermole process consisted chiefly in making tests of ores to find the applicability of the process to them. I was in the employ of Messrs. Sulman and Picard for about six months before entering the employ of Minerals Separation, Limited, but as my employment by Sulman and Picard was made with the approval of Mr. Ballot and my work there was entirely in
350 connection with Minerals Separation matter, the change of employment was nominal rather than actual.

When I started with Messrs. Sulman and Picard, I was first instructed in the use of the Cattermole process and afterwards assisted Mr. Chapman in testing ores to find the applicability of the process to them. In these tests I remember several successes and only one failure. The cause of the failure was the large amount of soluble carbonate contained in the ore and the effect of this soluble carbonate was to prevent granulation.

Q. 15. I presume the presence of carbonate incidentally (313—237) has the effect of causing the consumption of a larger amount of acid than otherwise would have been the case?

A. Certainly.

Even when large amounts of acid were used, still the desired granulation did not take place by reason of the amorphous precipitates produced, which absorbed oil in preference to the sulphides.

In the Cattermole process, the mixture of ore, water, oil and mineral acid were first agitated in what was commonly known as the Gabbett mixer. Thereafter a further agitation took place in a modified Gabbett mixer, that is to say, the baffles were removed.

The violent agitation produced incipient granulation and the more gentle agitation afterwards perfected the granulation. The size of the granules depends on the nature and duration of this second agitation. This two-stage agitation was in use in the Cattermole
351 process when I was instructed in the process by Messrs. Sulman and Picard and was adhered to in the subsequent practice of the Cattermole process and was considered the best way of carrying out the Cattermole process. In the Cattermole process different results were secured with different oils and mixtures of oils, and different oils and mixtures of oils had to be used in very slightly different quantities and also in different ways. In general we used 5% of oil on the mineral, which was increased perhaps to six or seven per cent and decreased to three or four per cent. By mineral I mean the metalliferous constituents of the ore being treated.

The degree of agitaition in the Cattermole process is not quite so violent as that used in the process referred to in the patent in suit, if the results are to be expected in the same time. If you use the same degree of agitation (314—238) the result in the process of the patent in suit require longer time for their production than is the case in the Cattermole process.

I was instructed in the essentials of the Elmore buoyancy process while a student at the Royal School of Mines.

Q. 30. What was the occasion of Messrs. Sulman & Picard instructing you in December, 1903, and January, 1904, in the use of oils or fatty matter for flotation of part of the constituents of an ore?

A. I believe it was simply to give me all the information they had on oil processes.

Q. 31. And what information did they impart to you at
352 that time?

A. As far as I remember, it was an alternative to the Cattermole second agitation, and consisted in the use of air, introduced or generated in the pulp containing the agglomerations or imperfectly granulated mineral, for the purpose of bringing this up to the surface as a scum.

My researches in connection with the Cattermole process were not directed towards improving that process, but in improving the application of it I certainly tried some experiments. The form of apparatus first used by me in applying the Cattermole process included a series of four Gabbett mixers followed by a spitzkasten with cylindrical sides. The pulp, after being agitated and passing through these four Gabbets, passed into the spitzkasten where the separation of gangue slimes from the remainder was effected. The remainder passed into two succeeding Gabbett mixers running at a lesser speed than the previous four, where the granulation was perfected. The pulp then passed into (315—239) another cylindrical spitzkasten, where the gangue was washed out in the overflow and the granules fell out in the underflow. There were baffles in the first four mixers, but none in the last two, that is, the fifth and sixth mixers. I found this apparatus constructed and in use in the

laboratory of Messrs. Sulman and Picard in December, 1903, when I entered the employ of Messrs. Sulman and Picard.

My experiments in the application of the Cattermole process were chiefly in the use of different oils in different emulsifications.

353 Q. 43. Were the quantities of oil and acid to be used a subject of interest at that time?

A. I do not remember anything being said about the quantity of oil, except the quantity used was always adjusted to give granulation.

Q. 44. In adjusting the oil to give the best granulation, I presume you experimented with different quantities of oil.

A. Yes, there may have been different quantities, but whenever the granulation became imperfect by reason of the drop in the quantity of oil, the oil was naturally increased.

I first learned of the Froment process early in 1904. There were three pieces of apparatus lying about the laboratory, and I inquired of Mr. Chapman as to their use. He explained that they were for carrying into effect the Froment process and briefly explained the process. The first piece of this apparatus consisted of a cylindrical vessel, with a small hopper attached to the side of the vessel, the whole capable of holding ten litres or so of water. The vessel contained two stirrers, consisting of (316—240) short horizontal arms carried on two elliptical frames. The latter could be rotated in opposite directions by means of gearing ending in a handle. The second piece of apparatus consisted of a cylindrical vessel, with a spout carrying at the bottom a double coiled lead pipe, with perforations. A rake was suspended in this vessel so that the contents could be stirred. The third piece of apparatus consisted of a

354 wooden box carrying an aluminum sieve and a cam shaft for agitating the sieve. Pipes in this wooden box allowed the contents of the box to be drawn off at different places.

I performed one or two experiments in connection with the Froment process, using the apparatus above referred to. I do not remember performing any considerable number of experiments as the results of the few I performed were hopeless.

After the performance of these experiments, the Froment apparatus was put aside. I cannot say what finally became of it. I have made a search for it recently, and have not found any part. It undoubtedly has been scrapped. I certainly saw it in the laboratory of Minerals Separation, Ltd., in the beginning of 1906, but I have no recollection of having seen it since.

Q. 53. Do you know whether anyone else experimented with the Froment apparatus besides yourself?

A. I never saw anybody do so.

Q. 54. You would probably have seen them if they had experimented with it, would you not?

A. Certainly.

My instructions to experiment with the Froment apparatus probably came to me through Mr. Chapman, from Messrs. Sulman and Pickard. I do not remember that Messrs. Sulman and Pickard themselves personally gave me these instructions. I (317—241) do

not remember instructions to terminate the work. It is possible that it was interfered with by other work.

355 Q. 58. And it is quite probable, I presume, that you exercised your own judgment in the matter of proceeding with the Froment experiments?

A. No, I think I was working under Mr. Chapman's instructions.

Q. 59. What was the first occasion upon which you ever saw part of the constituents of an ore, which, in the form of a pulp, had been oiled, floating upon the surface of the pulp?

A. I cannot state the first occasion, as very small percentages of mineral frequently floated on the surface of the pulp contained in the spitzkasten during the operations with the Cattermole process. I do not think this proportion of mineral ever exceeded 5 per cent of the whole.

In experimenting with the Cattermole process I used the following oils: thick residuums, thinner residuums, thick residuums thinned with lighting oil, oleic acid and turpentine. The residuums referred to were chiefly petroleum residuums, but there were other residuums that I recollect using, such as residuums from wood tar distillations.

The first occasion upon which I ever saw the phenomenon of an oiled concentrate, the bulk of the concentrate, floating as a scum or froth upon the surface of a pulp, was while carrying out a series of experiments at the instructions of Messrs. Sulman, Pickard and Ballot in the early part of March, 1905. These instructions were given to me by Mr. Sulman and their nature was to carry out a series of tests on the factors influencing granulation.

356 (318—242) In the bulk of these experiments there was a small quantity of floating mineral. This only reached appreciable proportions when the reduction of oil was carried down to very small proportions. The quantity of floating material increased rapidly when the oil was reduced below a certain point, this certain point being .62 per cent of the oleic acid on the ore. My report of March 16, 1905, is the original record made in my handwriting of these investigations, and it was preceded by no written report or memoranda. The facts contained in this report had been orally reported both to Messrs. Sulman and Pickard and Mr. Ballot.

Q. 72. You mean that prior to your oral report you had made no laboratory memorandum or notation whatever of the percentage of oil and of the result secured?

A. No, I do not mean that. I used to keep a rough record of the experiments, which never left my possession.

Q. 73. What did you do when you first tried your experiments with oil reduced in quantity of .62 per cent on the ore; I mean did you immediately make your oral report that you have referred to to Messrs. Sulman, Pickard and Ballot?

A. I called in Mr. Ballot to see one of these experiments performed, wherein froth was produced, but I cannot say which one it was. I may, therefore, have tried a further reduction of oil before making an oral report on it.

Q. 74. You recognized that the formation of this froth
357 was not conducive to the granulation desired in the Cattermole process, of course?

A. I recognized that this froth was different from the Cattermole process, and could not, therefore, be considered either detrimental or advantageous to granulation.

Q. 75. Did you call in Messrs. Sulman, Picard and Ballot immediately or very soon after your experiment with (319—243) the oil reduced to the neighborhood of .62 per cent?

A. I cannot state the interval of time which elapsed between the performance of this experiment and the calling Mr. Ballot. It is possible that I made certain that this froth production was not accidental, and then called Mr. Ballot to see it.

Q. 76. Do you remember you noticed the appearance of the tailings when the froth was produced, for the purpose of forming an idea as to how complete a recovery was effected by the froth?

A. I feel certain I should do so.

Q. 77. And from the condition of the tailings I presume you noticed that the recovery was quite high?

A. I did.

Q. 78. Did you before calling in Messrs. Sulman, Picard and Ballot remove any of the froth by spooning or skimming?

A. I should probably have removed some of this froth and examined it to judge its value.

Q. 79. What apparatus was used by you in your experiments in which you reduced the oil to the neighborhood of .62 per
358 cent?

A. I was using a single Gabbett.

Q. 80. And when did the subject first come up of devising other apparatus for the purpose of continuing the investigation along the same lines?

A. I do not remember being consulted on this point.

The first apparatus which I saw designed especially for the purpose of separating the metalliferous mineral in the form of a froth in a continuous manner consisted of a series of Gabbett mixers for the agitation, and a compound spitzkasten, such as is described in the patent in suit, for the separation. In the production of a froth the operation of this apparatus was as satisfactory as the (320—244) single Gabbett apparatus first used by me. The separation of the froth, however, in the spitzkasten was not quite so complete as the apparent separation in the single Gabbett on stopping the cone.

Q. 83. I do not quite follow the distinction you draw between the production of the froth and its separation. Will you kindly explain?

A. The froth is produced in the liquor during the agitation, and is naturally mixed with the gangue. The formation of froth is not evident except from an indication known as the "clean-up." This can, of course, be made evident by stopping the agitation, when the froth is allowed to separate from the gangue. The operation of sep

aration I refer to is the actual act of separating the froth so formed from the remainder of the pulp.

359 Q. 84. And this act of separation, which I understand to be the actual stratifying or separating of the froth and gangue into separate layers, is what you referred to as not being so satisfactory in the spitzkasten of the continuous machine as in the single Gabbett — which you first experimented.

A. I did not refer to the actual stratifying, but rather to the separation of the different strata.

Q. 85. And it was this separation of the different strata that was not quite so complete in the continuous apparatus as with the single Gabbett with which you first experimented.

A. That is the meaning I intended to convey.

This continuous apparatus was, so far as I remember, in use when I left England for South America in the Spring of 1906. When I returned, about a year later, a different type of spitzkasten was in use.

Q. 91. After you had performed your experiments with (321—245) the quantity of oil reduced to the neighborhood of .62 per cent on the ore, and had noticed from the appearance of the tailings that the recovery in the froth was quite high, did it occur to you that a process of concentration might be carried out by separating this froth?

A. I was certain of it.

Q. 92. And did Messrs. Sulman, Pickard and Ballot agree with you in that?

A. Undoubtedly. I remember Mr. Ballot was particularly enthusiastic.

The instructions given to me regarding the Froment process, I think, I had early in 1904. The tests of this process which

360 I referred to were certainly in 1904, and a little later than the instructions. I fix this by the date of an incident. I am confident that I had been instructed in the principles of the Froment process before the Minerals Separation Laboratory was removed from Messrs. Sulman and Picard's at 44 London Wall to Aldermanbury Avenue, whilst the tests I refer to were, in my recollection, carried out in the latter place. As the occupancy of the Aldermanbury Avenue laboratory commenced in the Spring of 1904, as far as I can remember these tests were done in May or June, 1904.

Q. 99. Do you remember having made any formal or written report that would show the precise date when you tested the Froment process in the Froment apparatus?

A. No. At that time a good many failures were only reported orally.

I first learned in 1904, previously to the removal of the laboratory, that the Froment process was patented. In my experiments with the Froment apparatus I used an ore known as Nagyag containing copper, gold and probably (322—246) 10 per cent of soluble carbonates. I do not remember trying the Froment process in the Froment apparatus with any other ore.

Q. 105. Did you try the Froment process, using any other apparatus than that sent to Minerals Separation by Mr. Froment?

A. Yes. I made experiments in test tubes, and in the Gabbett.

361 In operating the Froment process I tried the same oils as we used for the Cattermole process, namely, the oils enumerated by me during my direct examination.

Paraffin oil, referred to in my report of March 16, 1905, is the same as lighting oil or kerosene.

Q. 115. In using these different oils in the operations set forth in the patent in suit, do you find it necessary in treating the same ore to use different quantities of these oily substances?

A. Referred to the same ore, the quantity used is generally the same, but referred to different ores, the quantity may be different.

Q. 116. Do you mean that in treating the same ore you use the same quantities of all of the different oils referred to?

A. I mean the same results can be obtained by the use of the same quantity, but commercial consideration frequently causes one oil to be used in less quantity than another.

Q. 117. Can you state what the smallest quantity is of eucalyptus oil that will produce a froth, operating upon, say, some one of the Broken Hill ores with which you have experimented?

A. The smallest quantity of eucalyptus which I have found in my experiments on Broken Hill ore to give a (323—247) satisfactory concentration as a froth, is half a pound to the ton of ore.

Q. 124. Of what oil can you use the smallest quantity in carrying out the operations of the patent in suit, and of what oil is it

362 necessary to use the largest quantity, in your experience?

A. Generally, I should expect the least quantity of oil to be one of the thinnest of oils, and the biggest quantity a thick oil, that is, referring to the same time for the agitation.

I have no knowledge that Minerals Separation, Ltd., has ever succeeded in treating the Nagyag ores by the operations set forth in the patent in suit.

I left England for Australia in August, 1908. (Witness then describes the apparatus for carrying out flotation operations which he found in Australia. He also describes the apparatus in use in the laboratory of Minerals Separation at the time he left for Australia, known as the Australian Model Plant.)

The nature of my present duties for Minerals Separation, Limited, is testing, or supervising testing, operations on samples of ores; also experimental work in improving processes.

Cross-examination:

The instructions which I received from Messrs. Sulman, Pickard and Ballot, pursuant to which I carried out the experiments described in my report of March 16, 1905, were, so far as they related to the quantity of oil, to start with large quantities of oil, say the upper limit of Cattermole's specified quantity, and reduce this as far as possible. In other words, to find the lowest limit at which 324—248) results could be obtained by the use of oil?

X Q. 140. And how far, in fact, did you, in carrying out these instructions, reduce the quantity of oil?

363 A. 0.1 per cent is the lowest quantity of oil I reported as having used, although the absolute vanishing point, where no oil was used at all, was tested.

X Q. 141. You have referred to some floating material appearing at times in your work on the Cattermole process prior to March, 1905. Was this deemed an advantage or a disadvantage in that process?

A. It was deemed such a disadvantage that I arranged a piece of apparatus on the plant, which I called an "air-trap," to separate these floating flocks from the pulp before entering the spitzkasten. The flocks so separated were passed to the fifth mixer, where they were destroyed.

In my report of March 2, 1905, in the first paragraph thereof, I speak of other conditions which suggested their importance in altering the time of granulation. One of these conditions referred to the relation between the size of the cone and the mixer or jar forming the Gabbett. I think the others were of little importance as far as I remember. One was the use of insoluble soaps in granulation.

The metalliferous minerals content of the Broken Hill ore used in my operations wherein froth production first appeared was roughly about 50 per cent of the ore.

X Q. 145. After the froth had been produced in the single Gabbett, what was done to remove it or separate it?

A. Mr. Ballot desired to know the weight of the froth and requested me to remove it by introducing a long-stemmed

364 funnel and by pouring water down the funnel, causing the froth to overflow the top of the Gabbett into (325—249) a basin placed beneath. Experiments were also made in scooping this out with a spoon, and later the pulp was discharged into a spitzkasten. At an early date Mr. Sulman brought an apparatus that he had had constructed, consisting of a septum passing through the vessel, which could be drawn through when the froth had been formed, and thus remove the froth bodily.

The Commissioner notes that all of the documents marked for identification were handed to defendant and his counsel for examination, and copies thereof supplied, as requested.

The defendant closes his case. (326—250)

Rebuttal Testimony for Complainants of George Albert Chapman.

LONDON, ENGLAND, August 22–27, 1912.

Direct examination:

I am thirty-one years of age, a resident of London, by profession a metallurgical engineer and assayer. I am employed by Minerals Separation, Limited, in carrying out tests on ore, investigating processes, erecting, directing and operating plants in various

parts of the world. I received my technical education at Battersea Polytechnic, London, where I was a student for five and one-half years, I was instructed in chemistry, physics, metallurgy and engineering. In the year 1899 I entered the employ of Henry Livingstone Sulman, as assayer and metallurgical assistant.
365 Commencing in 1900, while so employed, I carried out tests of the Elmore bulk oil process of the Robson & Crowder process, which is an oil washing process of ore extraction. On Mr. Cattermole's introduction to the firm I acted as his assistant and finally, in Mr. Cattermole's absence, I assumed his duties. About this time I was appointed by Messrs. Sulman & Picard to carry out tests, under their instructions, on the Wolf or Scammel process. At a later period I was engaged chiefly in investigating the Froment process and later still the Sulman & Picard bubbles and skin-flotation processes, the Cattermole. Sulman and Picard Soap process. This brings me to the end of 1903.

I tried the Froment process in the apparatus sent by Froment to Minerals Separation, Ltd., but it required very few tests to demonstrate that the apparatus was entirely unworkable and I abandoned its use. In this series of tests of the Froment apparatus I used Broken Hill crude ore to which was added 10 per cent of calcite. (327—251)

I only used the first two portions of the apparatus forwarded. namely, the agitator and the separating pan. My reason for not using the third part of the apparatus was that it was too large to be conveniently erected in Messrs. Sulman & Picard's laboratory. To get an idea of the merits of this portion of the apparatus, I tried many tests on small screens under the conditions suggested by Mr. Froment. These screen tests determined that this latter part of the apparatus was also unworkable. Only by the most careful
366 nursing were any flocks of mineral persuaded to remain on the screen.

After consultation with Messrs. Sulman & Picard I determined to make every effort to get this process to work in some simple and practical manner. For the agitation part of the process I used one of the Gabbett or cone mixers installed in the laboratory. I usually took 1200 cc. of water and 500 grammes of crushed Broken Hill crude ore, to which was added varying quantities of oil from 60 lbs. per ton to 120 lbs. per ton. The pulp was vigorously agitated until the metalliferous sulphides were coated with the oil. The only method by which I could obtain a satisfactory separation of the sulphide mineral from the worthless gangue was to take the charge from the Gabbett or cone mixer and allow it to stand in a basin for settlement. The clear liquor was decanted off, and a thick mud remained in the basin. To this thick mud was added ten per cent of finely crushed calcite, which was thoroughly mixed by stirring with a spatule. The charge was then placed upon a plaque in small portions, say of about 50 or 60 grammes. The plaque was then placed beneath the surface of slightly acidulated water. The acid attacked the calcite, and this had the effect of causing (328—252) the sulphide mineral to separate itself from the gangue in the form of flocks

of pasty oiled mineral. These masses of mineral did not always float to the surface of the acid liquor, but the attached gas bubbles caused these flocks to be comparatively lighter than the gangue, and in this condition they could be easily separated by a simple
367 vanning. The plaque was withdrawn with the gangue contents and the mineral collected from the vessel containing the acid liquor. The concentrates recovered were therefore separated in two distinct manners: First, the portion of the concentrates that were lifted bodily by the gas to the surface of the liquor, and, secondly, the portion of the concentrates that were rendered light by the gas association which were vanned by the usual well-known methods. By this latter method fairly good separation of sulphide minerals was possible, and in my opinion this is the only method by which the difficult Froment process can be made to give any resemblance to a practical separation.

Under Messrs. Sulman & Picard's instructions I carried out a large number of trials, investigating the Sulman & Picard Bubbles process. Part of this work was carried out on the lines just given.

Considerable time was spent in constructing a small glass apparatus of the type given in Figure 1 of Patent No. 793,808. This was made of glass to enable a full view to be had of the separation. The tailings from the Cattermole process containing sunken flocks of mineral were placed in the apparatus and air pumped into the perforated spiral, which was rotated slowly. The results from this apparatus were most encouraging. This apparatus was also used to bring about the Froment effect. The Cattermole tailings were mixed as described before with ten per cent (329—253) of crushed calcite, and instead of passing air through the perforated spiral a
368 solution of weak sulphuric acid was introduced into the separating vessel by this means. Good flocks of mineral separated from the gangue, many of which, although carried up to the surface of the liquor, did not break through the surface film. The associated gas bubbles detached themselves and the mineral sank and became mixed with the residue or tailings.

Another type of apparatus used took the form of an ordinary scent spray. This apparatus was used in several manners. First it was used to force finely disseminated oil into a vessel containing crushed ore and water. This method of bringing about oil attachment to the sulphide mineral proved to be very poor. Second, a pulp of crushed ore and water, which had been suitably agitated with oil, was placed in the scent spray. The pulp was sprayed on to the surface of still water. A separation of the sulphide mineral from the gangue was quite apparent, the mineral floating by means of the well-known oiled needle effect and the gangue sinking through the water.

7 Q. You have mentioned the introduction of Mr. Cattermole to Messrs. Sulman & Picard and that you acted as his assistant. What work did you do as his assistant, and with what process or processes?

A. We were chiefly concerned in testing ores by the granulation or Cattermole process. The apparatus used to carry out this

process consisted of a series of Gabbett or cone mixers, which were six in number for the first agitation. This first agitation
369 was of a very violent type to bring about the oiling of the sulphide mineral. The agitated pulp was then passed to a small glass upcast separator where the fine gangue slimes were washed from the pulp, (330—254) allowing only the oiled metalliferous particles and the coarse gangue to pass to the second stage of the process, which consisted of slowly rolling in the same type of mixer as used in the first stage, but with the baffles taken out and the speed of the cone much reduced. This slow rolling had the effect of causing the incipient granules to make combination amongst themselves, and the rolling was continued until the mineral worked into the form of hard shotty granules. In the second stage of the process it was highly important to prevent air attaching itself to the mineral, and this was the reason for taking the baffles out and reducing the speed. After the slow rolling, the treated pulp then passed to a second upcast classifier where the gangue was washed from the shotty granules. The granule product usually carried only about 3 per cent of insoluble gangue matter. First investigation determined that the granule formation in the slow rolling stage was much improved if the fine slime gangue was removed before this stage of the process was reached. Excellent results were obtained by this method, and on Broken Hill crude ore we on many occasions obtained 90 per cent recovery of the three valuable metals, namely, silver, lead and zinc. After the success of this process was fully established in the experimental stage we were chiefly concerned in devising a breaking-
370 down method to separate the mixed concentrate of galena and blende into the more saleable separate lead and zinc concentrates.

I was assisting Mr. Cattermole in this work when I was called upon to take up other investigations.

8 Q. Please continue as to your further work with the Cattermole process so far as you carried it on in England. (331—255)

A. In or about December, 1903, I was instructed by Messrs. Sulman, Picard & Ballot to erect a small Cattermole plant, of the type described in my last answer, for the purpose of installation in Australia to carry out tests on the ore and mill products of the Sulphide Corporation, Central Mine, Broken Hill. This plant was erected at the works of W. M. Still & Co., Charles Street, Hatton Garden, London, under the superintendence of my instructors. The photograph marked for identification "Photograph Australian Cattermole Plant" is a photograph of this plant as it was erected prior to dissembling and shipment to Australia. This plant was thoroughly tested before taking it to pieces for shipment, and it was at the period of these tests that I was first introduced to Mr. A. H. Higgins, who acted as my assistant in the final London trial. We satisfied ourselves that good results could be reproduced with this plant and on reporting this I was immediately instructed to leave for Australia.

In testing this plant at Still's, the ore used was Broken Hill crude

ore of 55% mineral content. The proportion of oil used
371 and set as a standard for future work was 5% on the sulphide mineral constituents or mineral content of the ore. The oil was added in the form of an emulsion and also in the form of straight oil. Oleic acid was very often used. All our later work was conducted on emulsions containing oleic soap.

13 Q. You have referred to the Cattermole, Sulman and Picard soap process. What did you do in connection with this process?

A. In connection with the work on this process we took advantage of the soap phenomenon in which, when it came into contact with the acid liquor, the oleic acid was (332—256) produced in situ. This was used in the Cattermole process as I have described. The second part of the process was merely a means of attempted recovery of flocks of mineral that had passed over with the gangue from the upcast and had sunk. We took advantage of the Froment effect in this latter portion of the process. Although at times we had indications that were encouraging, no practical good resulted from our efforts to make this latter part of the process into a commercial process. This soap process was applied to the treatment of the crude ore direct without the intervention of the Cattermole separation and total flotation attempted. The results, however, were, most discouraging and work was stopped on these lines.

14 Q. In the last sentence of your last answer it is not quite clear in what manner the soap process was applied to the treatment of the crude ore direct, without the intervention of the Cattermole
372 separation, that is to say, whether it was as you have described with the Froment effect, or without the Froment effect. Please explain more fully.

A. Oleic soap was added to the crude ore and water in the Cattermole proportions and agitated in the usual manner up to the first upcast. The pulp from this was taken and a Froment separation attempted in the manner in which I have described previously.

I left England for Australia for the purpose of installing the Cattermole process in Australia, in or about April, 1904. When I reached Australia, I re-erected the plant on the property of the Sulphide Corporation, Central Mine, Broken Hill, and started testing the plant with crude ore from the mine. These tests were most successful, and on the result obtained our clients immediately proceeded with the planning and erection of a plant on identical (333—257) lines with the smaller unit which had been tried. The new plant was to have a capacity of 100 tons per day of 24 hours. The large scale Gabbett agitators were in exact duplication of the smaller mixers, except that they were made of wood, with flat bottoms. Triangular strips of wood were fastened to the sides to take the place of the wire baffles used in the smaller mixers. A nest of six connected mixers constituted the first part of the plant. At the end of these mixers a small upcast was in position to separate the slime gangue to bring the pulp in the condition desired for the slow rolling in a second tier of mixers, in which there were three mixers, a
373 duplication of the agitators of the first series, except that the baffles were removed and the cones were much reduced in

speed. From these the pulp passed to another upcast separator. Below the second series was another series of two agitators, in which baffles were fastened and the cones again speeded up. The pulp from these last two agitators was divided and passed over four Wilfley tables, upon which the riffles were modified. The object of the baffles was to recover by skin flotation any mineral flocks which had been lost with the gangue product. This plant was completed and adjustment runs made in or about April, 1905. We started the plant on dump tailings, and treatment proceeded along the Cattermole lines for but a few days. The oil consumption alarmed our clients, and I was instructed to use every endeavor to bring this down. This was only possible to the extent of .8 per cent of the weight of the ore. The formation of good shotty granules was impossible under these conditions, mineral flocks being formed, and these readily separated on the skin flotation table on the lines in which I had been instructed by (334—258) Messrs. Sulman, Picard and Ballot previous to my departure for Australia. These trials took considerable time and it was a few weeks before this best condition was reached. The plant proceeded to run on these lines.

Q. 23. What next happened which brought about any change in this plant?

A. In or about the month of June I received instructions
374 from Mr. C. F. Courtney, general manager of the Sulphide Corporation, Limited, to modify the plant so that we could take advantage of a very important discovery that had taken place in England. He handed me a drawing which gave the details of the process which was exactly the same as the drawing marked for identification "Sulman Drawing accompanying report May 3, 1903." Owing to the trouble which had been met with in working our previous method, as a practical man, I was very much gratified and relieved to know that we could substitute this more simple and ingenious process.

24 Q. What did you do with the plant when you received these instructions?

A. In the position occupied by the second tier of mixers a spitz box was placed into position. A connecting launder from No. 6 agitator of the first nest to the spitz box was introduced. The bottom outlet of the spitz box was connected to our previous table arrangement so that we could take advantage of skin flotation effect to recover any mineral that had been lost in the first separation. This is identical with the scheme suggested by the drawing. A steam pipe was introduced into the first and last mixer of the only tier now in use. The plant was started up under these conditions, and the pulp received a violent agitation and was passed down the launder to the spitz box. (335—259) On the surface of the spitz box, at a point where it was perfectly tranquil, a substantial
375 froth formed. This was entirely different to any float that I had seen in the other processes in which flotation had been attempted. This froth had many characteristics, and the most important difference I noticed in comparison with the other floats was that the froth was of the same color as the mineral and of the

same lustre. This had never been so in the other cases, where the oil had considerably dulled the natural color and lustre. The froth consisted of air bubbles, with water films that were highly charged with sulphide mineral. These bubbles could not retain their natural spherical shape, owing to the crowding together of the froth mass. The upper layers of bubbles, when they broke, deposited their charge of mineral on to the bubbles beneath. This gave the froth a pitted or scoriated appearance. The depth of the froth at the point of overflow was quite three inches. The froth was so coherent and substantial that it would readily support a coin, which it would carry over the overflow lip without breaking through the mass. We used this to demonstrate to visitors at a later date. The tailings from the spitz box then passed to the tables for retreatment, where many types of air jets were applied in the hopes of improving the recovery. The work on these tables was never really satisfactory, and an examination of the tailings showed the sulphide mineral losses to be in the form of a potential froth. A few experiments showed that it was only necessary to give these a slight agitation to bring about further air-bubble attachment, and this potential froth then became a real froth on
376 passing it to another spitz box. This second spitz box was placed immediately below the first spitz box, and the tailings were brought (336—260) with a good splash on to suitable baffles and boards of the second spitz box. From this date onward the tables for the retreatment of tailings from flotation treatment were discarded.

When the plant was changed to collect the mineral in the form of a floating froth as I have described, we used 2 lbs. of oleic acid per long ton of ore. We retained the same Gabbett or cone mixers that were used in the first treatment of the Cattermole plant.

Owing to the high consumption of power by the cone form of agitator, we made successively various improvements in the form of agitator until we adopted the ordinary four-arm agitator and in this we made various improvements to minimize wear and increase the aeration and save power. These changes in the type of agitator were very effective in their saving of power, fully 60% of the previous consumption being saved. These alterations were always completed during our Sunday stops and did not interrupt the operation of the plant.

In all the new plants which we erected, we discarded the circular form of agitating vessel and used the ordinary square box agitator, a type recommended by Gabbett. These new plants were the No. 2 Flotation Plant at the Central Mine, Broken Hill; the Slimes Treatment Plant of the Sulphide Corporation, Limited, the Zinc Section New Mill, and the Minerals Separation Tailings Plant, both
377 of which were on the property of the Sulphide Corporation. These had a total capacity of over 10,000 tons per week. I superintended the construction of these plants.

(The witness then described the construction and successful operation of the several plants above referred to.)

In the Slimes Treatment plant the thickness of froth (337—261)

very often reached five or six inches and it was necessary to slightly increase the area of the spitz box. Owing to some peculiar condition this thick froth discharged itself from the box very badly and it was necessary to introduce a small four-arm paddle device which revolved slowly and assisted the froth over the lip. Owing to the very slimy nature of the feed it was necessary to restrain the froth overflow as much as possible, so that no free liquor passed over the lip with the froth. This was to bring the proportion of gangue in the recovered concentrate to a minimum. The feed to this plant, consisting as it did of dump slime, was sufficiently powdery for the treatment by the frothing process. It was only necessary to pass the dump slime through a clay puddler with a little water to break up the large lumps.

The consumption of oil in these several plants which I 338—261*a*) have described was about 1½ lbs. per long ton of ore. All these plants were a great success and considerably influenced the increased profits earned by the Sulphide Corporation, Limited, in the past few years.

378 Early in 1907 I was consulted by the then superintendent of the Zinc Corporation Works at Broken Hill, who confirmed the information that this corporation intended to install the agitation froth process. I visited the existing plant of this corporation which was then operating the Potter process. I was instructed to prepare plans for changing over the Potter process to the agitation froth process and submitted plans of the works then in progress on the Central Mine, Broken Hill, which gave full details of the Gabbett mixers and spitzboxes. It must be fully understood that I advised only in regard to the treatment section, that is, that portion of the plant that was actually to operate the agitation froth process. The erection of the plant was done by the officers of the Zinc Corporation, Limited. When the plant was ready, I impressed upon their superintendent with considerable emphasis the necessity of submitting to our treatment a suitable feed, that the crude tailings should be crushed to a half millimeter in size, and be fed regularly with all its slimes to the treatment plant. I drew upon my own crews of men, then working on the flotation plant of the Central Mine, and lent them sufficient men to run their flotation plant until such time as they had trained their own crew.

The feed and crushing arrangement of the Zinc Corporation plant were very poor and resulted in unsatisfactory operation of the agitation froth process. This was entirely due to bad powdering of the ore and the bad arrangement for a regular

379 feed. The crushing machines were totally (339—262) inadequate. My instructions regarding the condition of the powdered feed were never carried out. My position only being an advisory one, I could only point out the mistakes being made, but was never given an opportunity to rectify them.

The agitation froth process section was planned to have a capacity of 480 tons per day of 24 hours. If the crushing section had been in good working condition and in a state of thorough repair, this

section would no doubt have handled, to my satisfaction, about 290 to 300 tons per day.

A few weeks after the agitation froth process started operations for the Zinc Corporation, a change in their Broken Hill management took place, and Mr. D. P. Mitchell became superintendent. During Mr. Mitchell's regime the plant was operated on tonnages sometimes exceeding 500 tons per day. It was on very few occasions that all the machines of the crushing plant were working. Irrespective of these stops, every effort was made to exceed 500 tons in the full day of 24 hours. On occasions, dump tailings were passed through without first being powdered to the size required. They should have been reduced to half a millimeter, whereas they were the result of three millimeter crushing and received no further powdering. I called Mr. Mitchell's attention to this bad arrangement and again impressed upon him the absolute necessity of delivering ore for treatment by the agitation froth process in a suitable powdered form. I reported the bad methods employed to
380 our then consulting engineer, Mr. C. F. Courtney, and suggested that the only way by which we could successfully operate our process for the Zinc Corporation was to assume charge of all the crushing and feeding arrangements. Mr. Courtney opened negotiations with this object in view and on the completion of the (340—263) discussion it was agreed that this should be done. As soon as this arrangement was completed and details being planned, the Zinc Corporation plant was shut down without notice and treatment by the agitation-froth process discontinued for the time being. I reported on this very fully to Mr. Theodore Hoover by letter dated August 16, 1907, which I now produce.

The letter produced by the witness is offered in evidence and marked "Complainants' Exhibit Chapman Report August 16, 1907."

At the time the Zinc Corporation discontinued the use of the agitation froth process plant, the No. 1 Flotation Plant of the Central Mine, Broken Hill, was in successful use, the Zinc Section New Mill was running for adjustment, and I believe the Slimes Treatment Plant had started operations, which operations were of the most successful kind.

44 Q. I call your attention to 33 X Q. and answer in the deposition of Mr. Herbert C. Hoover, and ask you to state the actual facts, within your knowledge, as to the incident there inquired about.

A. On the occasion referred to, Mr. H. C. Hoover was in Broken Hill. The plant was run under his direction while I was
381 present and operated on over 500 tons per day. I repeated to him the constant warning that I gave to his Broken Hill superintendent, Mr. D. P. Mitchell, namely, that although the agitation-froth section of the plant was quite capable and efficient to handle successfully 500 tons of correctly powdered feed per day, the crushing section of the plant was totally incapable of correctly handling this large tonnage. Mr. Hoover replied that for certain reasons it was absolutely necessary for them to be able to cable home that the plant was operating on an average of (341—264) 500 tons

of ore per day. I pointed out to him that if he forced the tonnage through the crushing section the recovery by the agitation-froth process would suffer. He assured me that for the time being this would not matter as the main point that they wished to confirm and prove was the capacity of the plant and the grade of recovered concentrates. When the standard set by Mr. Hoover was reached, namely, treatment of 500 tons of ore per day, and the production of a zinc concentrate assaying 46% zinc, he left Broken Hill for Melbourne. Before he left however he instructed me to consult with Mr. Mitchell, in order to bring the crushing requirements up to the standard desired. This I did with the results above stated.

45 Q. Mr. H. C. Hoover, has testified that Minerals Separation representatives in a general way had supervision of the operation of this plant. What have you to say as to this?

A. My position was only advisory and the first calls upon my time were in connection with the running and operating
382 of this Sulphide Corporation Limited flotation plant. I visited the Zinc Corporation Works three and sometimes four times a day. I had trained men in the agitation-froth section and I was sure that with the correct addition of powdered feed they would reproduce the excellent results that were being obtained in the plants erected in the property of the Sulphide Corporation limited.

Prior to the installation of the Zinc Corporation plant referred to, many tests were made and fully reported which proved that the agitation-froth process was equally applicable to the products from other Broken Hill mines and that under correct conditions of powdered feed the same good results could be obtained from the tailings that they had (342—265) bought as could be obtained in the treatment of Central Mine tailings. The tests were very severe and were carried out in the No. 1 Flotation Plant. A good coherent froth was obtained in every instance.

47 Q. I note that in your report of August 16th, 1907, to Mr. Theodore J. Hoover, which is in evidence, you state that this Report is "on the working of the granulation process on the British Mine." Please explain that.

A. As I have already testified the first large scale plant that I erected in Broken Hill was intended to operate by the Cattermole or granulation process. When the change over to the agitation-froth process was made the name "granulation process" was continued in use by the uninitiated. Even to this day in some
383 parts of Australia our plants are still known as "granulation plants." I used this name because it was the name by which the plant was known.

I left Australia in or about May, 1908. At that time the Zinc Section New Mill and the Minerals Separation tailings plant were running. Owing to the enormous success of the Minerals Separation Tailings plant, and the larger tonnages than anticipated that were being treated, the concentrates produced for shipment were in excess of that required to fulfill our contracts to the smelters, and, therefore, the No. 2 Flotation Plant was shut down. I should point out that

the latter plant, namely, the Minerals Separation Tailings plant, was operated at a very much reduced cost. Nearly 50% of the total working costs were saved in the later and more compact arrangement, the large tonnage also considerably assisting in this reduction. The bulk of the accumulated concentrates from these plants at the time I left Australia was about 450,000 cubic feet, (343—266) representing roughly 25,000 tons.

51 Q. You have said it is part of your work to carry out tests on ores. Please describe the manner in which you customarily test an ore for the purpose of determining whether or not it can be successfully treated by the agitation-froth process.

A. The ore to be tested is suitably powdered or pulverized. I usually use the Sulman & Pickard Slide machine, sometimes known as a "shear-mixer." Into this Slide machine I place sixteen hundred grammes of water and in it place 400 grammes of the ore
384 to be tested. I add acid to equal 20 lbs. per ton of ore to be tested and note the effect of such an addition. If a violent evolution of CO^2 takes place I know that calcite is present in the ore in disturbing quantities. By disturbing quantities I mean that the ore would require large quantities of acid in the treatment, and for economy's sake I abandon the test and use certain acid salts such as are advised in the patent in suit. The choice of oil for treatment is decided by the locality of the mine, and if possible I use an oil that is locally produced and is as cheap as possible. Having settled upon the acid condition I add roughly one and a half pounds of oil per ton of ore and agitate vigorously for about two minutes. The machine is stopped and the contents of the slide-machine examined. If a good coherent froth is not formed I know that I have to make some slight modification in the re-agents used. To anyone well-trained in the agitation-froth process it is a simple matter to adjust the conditions so as to produce a good, thick, matted, coherent froth. The contents of the slide machine are allowed to stand still for about a half minute. This is to allow a settlement of the gangue slimes. The top half of the mixer is drawn and in its travel it carries the agitation-froth (344—267) with it so that it can be suitably collected in a basin or other vessel. The machine is restored to its normal position and fresh water added to bring the total water up to sixteen hundred grammes as before. The pulp is then vigorously agitated, this time for about one minute.
385 This is to allow any potential froth lost in the first step of the operation to become a real froth, so that it can be collected in the usual manner. I then examine the tailings and if necessary repeat the operation to attempt the production of more froth. By the examination of the tailings can be determined whether the oily re-agent has been added in excess, for I know now that any sunken mineral in the tailings is due to semi-flocculent granulation which can only be produced under these conditions. If such proves to be the case I abandon the test and start treatment with smaller quantities of the oil.

I have not mentioned the temperature condition, but this is modified so as to allow the most economical consumption of re-agents.

In tests where warm liquors are used it is quite possible in many cases to economize in the time of agitation, which, although in a small test is not important, would prove to be an important detail in large scale work. To conclude, the condition of re-agents, that is to say oil, acid or acid-salts, are suitably combined with the temperature and agitation conditions so that the cost of operation would be at a minimum. In all the slide-machine tests that I have conducted I have never had to use quantities of oily re-agents outside those mentioned in the patent in suit. The greatest amount of oil that I have ever used in practice is 4 lbs. per ton of ore, and the smallest amount I have ever used in practice is one pound of oil per ton of ore. (345—268)

386 When I returned to London from Australia, the apparatus which I found in use at the London Works of Minerals Separation, Limited, were for the small experimental tests consisting of one or two glass Gabbetts or cone mixers with the necessary spitz boxes placed in position, and for the larger scale tests a plant known as the Australian Model Plant, which was used to conduct tests on parcels of ore at the rate of up to 300 or 400 lbs. per hour. This plant was a reproduction of the flotation treatment section of the several Australian plants which I have described, but on a much smaller scale.

In the latter part of 1908 another plant was built in the London works, a three-story plant. (Witness here describes the construction of the three-story plant.) Before September, 1909, when I went away to South Russia, a testing apparatus was erected at the London Works, consisting of seven agitators and three spitz boxes. (Witness then describes the plant known as Last Charlotte Street plant.) When I returned from South Russia a few days before Christmas, 1909, this same plant was in use.

On January 1st, 1910, I went to Emu, near Swansea, in Wales, where I was sent to assist in some tests to produce concentrates for the San Francisco del Oro Mining Company. When I arrived at these works, I found an apparatus installed there which was substantially identical with the plant last described by me. I remained at the Emu works for a period of, roughly, three months. While I was there and at about the end of February, Mr. James M. Hyde, the defendant, accompanied by Mr. T. J. Hoover and Mr.

387 E. H. Nutter, made a visit of inspection. On the day these gentlemen arrived the plant was shut down, owing to a breakdown of the main circulating pump. They stayed over another (346—269) day and waited until the plant was re-started. This was done the next day, and normal running conditions resumed. Mr. T. J. Hoover fully explained the operation of the plant and process to our visitors, and they expressed themselves as fully satisfied with what they saw. In the presence of these gentlemen this plant operated to produce a good, thick, coherent froth consisting of a mixed concentrate of galena and zinc blende. The thickness of the froth on the first spitz box was very rarely less than three inches, and the plant was a good demonstration of the type of work that could be accomplished by the agitation froth process. The capacity

of the plant was 50 tons per day of 24 hours, but it was not usually run continuously for the production of more than 15 to 20 tons at a time.

68 Q. Was it operated continuously or with intermissions?

A. The running of this plant was regulated by the supply of concentrate required for some zinc smelting tests that were being carried out by Messrs. Harrison & Wilding of the San Francisco del Oro Company, and when we had produced sufficient concentrate for their need we closed down the agitation-froth plant and then started up again when more concentrates were required. This was necessary owing to lack of storage room between our filter collectors
388 and the roasting furnace.

71 Q. What usually happened when you started up the operation of the plant? Was the production of a thick froth immediate?

A. The production of thick froth usually took place about two minutes after the feed had entered the first spitz box.

The defendant, James M. Hyde, in testifying as to what (347—270) he saw at this plant, was certainly mistaken. The mere suggestion by him that the float was very thin is in itself quite sufficient to prove that he was wrong. We would never have produced sufficient concentrates for the smelting tests if our froth had been very thin and scanty. The usual standard of work at this plant was good, but at times the tailings showed the presence of a considerable amount of sulphide mineral.

As to the statement of Mr. Hyde that the attendants were constantly making changes in the hope of achieving better results, this is certainly untrue. The only change that took place in the treatment of this ore was to test a soap that had been forwarded from London and I am sure that this soap was never tested in the presence of either of the three gentlemen or at that time.

I returned from South Wales to London shortly after Easter and saw the defendant at the London Works. Mr. Hyde visited the works daily and was conducting tests on different samples of ore with the assistance of Mr. E. W. Wilkinson. I remained in
389 the London Works until the beginning of June, 1911.

In December, 1910, the London Works of Minerals Separation were at 2 King John's Court, and the large scale testing apparatus was a flotation plant of the same capacity as the last Charlotte Street plant. This plant was built and running almost daily. (The witness describes the construction of the King John's Court Standard Plant.)

There was also at the back of this plant a unit erected known as the Nutter Differential Plant. The object of this plant was to take the concentrates from the Standard Plant and to retreat them to obtain a differential froth-flotation of the first recovered concentrate. It was also (348—271) used to obtain a high recovery of sulphide mineral in the form of a poor grade concentrate, and these concentrates were to be retreated in the Standard Plant. This Differential plant worked for some considerable time, but the results were not so good as they were expected to be, and work on it was

discontinued after the departure of Mr. E. H. Nutter in the Spring of 1911. This plant is shown and described in the British patent No. 23,949 of 1910 to Edward H. Nutter, Theodore J. Hoover and Minerals Separation Limited.

By poor grade concentrate I mean one that would contain a very high proportion of gangue contents mixed with valuable sulphide mineral. This was purposely done to obtain very high recoveries in the initial treatment.

390 When I left London in the beginning of June, 1911, I went to Orijarvi, Finland, to install an agitation froth process plant for the treatment of the various ores of the Finnish-American Mining Co. I installed this plant and it was most successful in its operation and obtained double the recovery of the valuable metals that was being done by the existing wet milling plant, where the powdered ore was being treated from Wilfley tables. I remained in Finland nearly six months, when I was recalled to London for research work. Thereafter I visited the Saxbergets Mine, at Rafola, Sweden, and there installed an agitation froth process plant, which was divided into two parts. The primary plant operated upon the powdered crude ore, obtaining a very high recovery of the zinc content. This concentrate was passed to a smaller retreatment unit where the grade of concentrate was improved. From the date of introduction of the agitation-froth process the production of concentrates on this mine was doubled, for the same quantity of crude ore treated. The concentrates recovered from the retreatment (349—272) plant were passed to magnetic separators where the worthless magnetic pyrites were removed. The concentrates from the magnetic separator were then passed to Wilfley and Krupp-Ferraris tables, to separate the mixed concentrate into the more saleable lead and zinc products. This series of retreatments were conducted on the concentrates without any special preparation. The small

391 quantity of oil on these concentrates rendered this unnecessary. When I left Sweden this plant was giving a recovery of over 90% zinc. This good work is still being maintained.

There was at this Saxbergets Mine, Sweden, an Elmore vacuum plant, consisting of two units. The use of this plant had been discontinued, and the old method of water concentration reverted to some time before my arrival in Sweden.

In the several commercial plants at Broken Hill, Australia, the oil used was oleic acid at the rate of about 1½ lbs. per long ton of ore. On two occasions only while I was there did we change the type of oil and this was merely for testing a speciman of fish oil and a soap known as Karsam soap, which is a petroleum soap. Neither of these tests was satisfactory. The acid consumption at these plants varied from 15 to 20 lbs. per ton of ore. Wherever I have used the expression "ton," I have meant the long ton of 2240 lbs., and I shall continue to mean a long ton unless I state to the contrary.

At the agitation froth plant at the Emu Works in South Wales we used principally oleic acid in the proportion of two pounds per ton. The acid consumption varied between 60 to 70 lbs. per ton, and with this acid consumption we could not determine by ordinary

testing the presence of any free acid in the spitzkasten. The acid was added in (350—273) small portions throughout the agitation stage of the process, being added at the mixers Nos. 1, 3, 5 and 7.

392 The object of this divided addition of acid was to economize the total acid consumption as far as possible. So that this may be fully understood, I should mention that the theoretical consumption, that is the acid required to neutralize the calcite in the ore and obtain an acidified solution, exceeded 100 pounds per ton. The result, in this instance, of using this quantity of sulphuric acid less than what was necessary for decomposing the calcite and producing an acidified liquor or solution was that we were enabled to produce a high grade concentrate at the expense of a reduction in recovery. This was the condition we were aiming for. The plant was never run for recovery, but only for the production of concentrates to test by the Picard briquetting-smelting process. The San Francisco del Oro Company had been fully informed of the recovery and conditions of treatment by the results of official trials that had taken place in London some time previously. They had all the recovery factors and they were chiefly concerned in carrying out smelting tests on the concentrates to determine whether the presence of fluorspar in these concentrates detrimentally affected the life of the zinc retorts used in the briquetting process.

In the agitation froth plant installed by me in Finland we used a mixture of oleic acid and eucalyptus oil: oleic acid .5 to two pounds per ton; eucalyptus oil .2 pounds per ton. The acid consumption was from 16 to 20 pounds per ton.

393 In the agitation froth plant installed by me at the Saxbergets Mine in Sweden, we used a very cheap locally obtained wood tar oil in the proportion of 4 lbs. per ton (351—274) of ore treated and the acid consumption was only 5 or 6 lbs. per ton. In speaking of acid, I refer to commercial sulphuric acid.

The capacity of the Finland plant was 50 to 75 tons per day of 24 hours. At the Saxbergets Mine the primary treatment plant had a capacity of 100 to 150 tons per day. The retreatment plant for the retreatment of the concentrates had a capacity of 50 to 75 tons per day. By day I always mean 24 hours.

In my experience with the agitation froth process I have found on every occasion that has come under my own personal observation that the results of tests in the slide machine were always improved in the actual working of commercial plants. The improvements were not only those of recovery, but in the consumption of reagents.

110 Q. What has been your experience when, in using the agitation-froth process on a commercial scale, with a normal and proper consumption of 1½ lbs. of oil per ton of ore, this procedure had been varied by increasing the oil feed to 2½ lbs. per ton of ore?

A. The mineral froth being produced on the spitz boxes loses at once some of its natural color and luster and becomes dull in appearance. The quantity of froth being recovered on No. 1 box is considerably lessened. The froth on No. 2 spitz is slightly increased and the same with No. 3 box. The tailings on examination

immediately show increased losses of sulphide mineral.
394 These losses take the form of well oiled agglomerations.

111 Q. And what has been your experience when the normal and proper feed to 1½ lbs. of oil per ton of ore had been diminished to ½ lb. of oil per ton of ore?

A. The froth being recovered immediately diminishes (352—275) in quantity and the color shows the presence of slime gangue. The supporting liquor of the spitz-box immediately changes in appearance and shows the natural color of the ore slimes. The tailings become very dirty and show no sign of what we know as a good "clean-up." In fact the whole treatment suffers and unless the oil feed is restored to its normal condition a serious drop in recovery takes place with the production of a lower grade concentrate.

112 Q. Please state what, if anything, you did in testing the ore of the Braden Mine in Chili.

A. I carried out a large number of tests on this ore chiefly confining myself to determine the extent to which the ore had to be powdered before treatment. I determined that this ore had to be crushed to 80 mesh (Institute of Mining and Metallurgy Standard Screens). The treatment of the ore was simple and was carried out at ordinary atmospheric conditions. The acid consumption was 5 to 6 lbs. per ton. The oil consumption was 3 lbs. of Texas fuel oil and about one lb. of American wood tar oil per ton of ore. We obtained recoveries of 85 to 95 per cent of the copper content in a concentrate assaying 10 to 15 per cent of copper, the
395 original ore content being roughly 3 per cent of copper. These results have been considerably improved in practice, and the installation of a very large plant at present 1,200 tons per day, is now taking place as a result of the trials carried out in a 250 ton per day testing unit.

I am the communicator named in British patent No. 17,328 of 1906. I made this invention while I was in Broken Hill, Australia. The method here patented afterwards became the general practice of my company.

Our practice in Australia was to use the water in a (353—276) closed circuit. This was done because of the high cost of water, but it resulted in a beneficial advantage in that the effect of the acid salts and traces of free acid in this water was to cause a very quick settlement of the slime gangue in the pulp thickeners or dewaterers from which the pulp was fed to the agitation stage of the process. This enabled us to economize in settling space and largely assisted us in the saving of room. The acid which I refer to is sulphuric acid.

In No. 1 Flotation Plant the retreatment of poor grade concentrates occurred about once a week. In the Minerals Separation Tailings Plant the retreatment of concentrates was practically continuous.

(Witness identified a drawing representing the plant installed at the Emu Works, Wales, and the last plant erected at the Charlott

Street works of Minerals Separation, London, and the drawing was offered in evidence as "Complainants' Exhibit Drawings of
396 1909 and 1910 Agitation Froth Plants.")

Briefly describing this drawing: A are the mixers, B are the spitz boxes, C are the air lifts or pneumatic pumps which deliver the tailings for the next step in the treatment, D are the air feed pipes, E are the rubber flanged connectors connecting the agitator to the spitz-boxes, F represents an inclined deflecting baffle which is fixed in each spitz-box.

In the tests made by me of the Elmore bulk oil process and heretofore referred to by me, the proportion of oil relatively to the ore varied according to the ore being tested. I used a minimum equal weights of oil and ore, and as a maximum the oil three times the weight of the ore. We did everything we possibly could to make the mixture of (354—277) the ore pulp and oil to be of a most gentle type, and it was our aim to avoid any breaking up of the oil. No aeration took place.

Cross-examination:

These experiments in connection with the Elmore bulk oil process were carried out by me under instructions of Messrs. Sulman and Picard, and were tipping tests on various samples of ore in a glass cylinder.

I took a glass cylinder that would hold 1200 cc. of water and in this placed 100 grammes of crushed ore. To the ore would be added 600 to 800 cc. of water. Upon this would be placed 100 grammes of thick residuum oil. The stopper would be placed in the cylinder and the cylinder was then gently tipped or revolved in a
397 vertical direction. I would exercise great care not to break up the oil which would bring about a frog's spawn effect. After about thirty tips, that is to say fifteen vertical revolutions of the cylinder, I would let the water pulp settle. I would then draw off the oil by means of a spatula and transfer this to a basin. An examination of the tailings would show whether a good recovery of the sulphide content had been obtained. If this showed the presence of sulphide mineral I added a further 100 grammes of oil and resumed the tipping. After another thirty tips I would stop the test and draw the oil off as before. If necessary this would be carried out three times. The oil would then be thinned down by means of a thinner oil such as paraffin or benzine and the concentrate collected on a filter. These were weighed and sampled for assay. From the assay and weight of the crude ore and the weight and assay of the recovered concentrates the recoveries could be calculated.

These Elmore experiments were carried out to investigate (355—278) two processes owned by the Elmore Company. One was the treatment without acid, and this was followed some little time later by one in which acid was used. The experiments were tried both with and without acid. I also experimented with an apparatus which was a section of an Elmore cylinder containing one complete revolution of a spiral.

The Robson-Crowder oil washing process consists of mixing powdered ore with about 30% of its weight in water. After
398 thoroughly wetting the ore a light oil is washed through the mass, the intention being for the oil to wash out the sulphide mineral and allow the tailings to remain. This process required an enormous bulk of oil compared with the bulk of ore being treated. The valuable constituents are recovered by an oil-wash and not by an oil-float.

The Wolf or Scammel process with which I experimented is an improvement on the Elmore bulk oil flotation process. It consists of submitting the oil to be used to a treatment with sulphur-chloride. This treated oil had the effect of remaining in an unbroken condition more perfectly than the Elmore untreated oil. The tests were carried out in the same manner as those described in the previous answer referring to the Elmore bulk-oil process.

The apparatus sent by Mr. Froment to Minerals Separation consisted firstly, of a mixing vessel standing on three or four legs. The agitation consisted of wire beaters revolved by means of a handle suitably geared to the spindle carrying the beaters. The separating pan consisted of a cylindrical vessel in which two lead coils were laid side by side on the bottom. Above this was a scraper intended to impart a slight disturbance to the ore in the separating pan. One of these coils could be used for the feeding of acidulated water. Usually sulphuric acid was used. The (356—279) other coil I never had occasion to use, but was given to understand that this was to keep the oil in a fluid condition by means of steam passing through the coil. The third portion of the apparatus, which
399 I never used, consisted of a screen on which it was intended to collect the oily flocks of mineral left in the tailings and would allow the tailings to pass through the screen.

I never saw any steam connection made to the coil in the second element of the Froment apparatus.

137 X Q. You have referred to a small glass apparatus of the type shown in Figure 1 of the drawings of Patent 793,808 and have said that tailings from the Cattermole process containing sunken flocks of mineral were placed in the apparatus and air pumped into the perforated spiral which was rotated slowly. Why do you refer to these as "sunken flocks"?

A. These flocks of mineral or imperfectly formed granules passed over with the upcast water from the upcast classifier. These sank to the bottom of the collecting vessel with the rest of the tailings.

I have tested the operations set forth in patent 835,120 in suit by performing those operations in a bottle. I took a bottle of about 100 cc. capacity, placed in it 20 grammes of ore and 70 grammes of water. To this I added sulphuric acid equal to about 20 lbs. of acid to the ton of ore. To this I then added oil by drops equivalent to 1½ to 2 lbs. of oil per ton of ore, and agitated the bottle and contents vigorously. These tests would serve as an indication only, and would be used to indicate the condition for the first investigations when using the Sulman & Picard slide machine. I would

never use a bottle test to obtain quantified results and would
400 only use it for the reason I (357—280) have just mentioned.

I have tried the Froment process in a test tube and find that the results were of a most unsatisfactory nature and dangerous to the operator. On the final addition of acid to the calcite the whole contents of the test tube would spurt up and great care would have to be exercised to prevent any of this material getting into the eyes.

I could not say with any degree of certainty if I had ever seen the Froment patent at the time I performed my experiments and tests of the Froment process, but the patent and apparatus were fully explained to me by Mr. Sulman. I am not sure that I had seen the Froment patent when I experimented to ascertain whether the process of the Froment patent could be carried out. I was working entirely under the directions of Mr. Sulman, who carefully watched my work. At the time I was experimenting with the Froment process I was not shown the instructions sent by Mr. Froment to Minerals Separation, Ltd., but these were conveyed verbally to me by Mr. Sulman.

When I experimented with the apparatus which Mr. Froment sent to Minerals Separation, Ltd., the beaters in the agitator vessel were worked by hand and naturally the agitation would not be of a violent type. The agitation continued until it was seen that the sulphide mineral was coated with oil. I had no definite instructions as to the speed of the beaters, but the object of them was fully explained, inasmuch as the sulphide mineral had to be oil-
401 coated. To ascertain when the sulphides were coated with oil, I would take a small portion of the pulp from the mixer and examine it on a plaque. The oiling of the mineral would be apparent at once. It made itself apparent by the fact that the mineral would collect in flocks, lose its (358—281) natural color and luster and be quite oily to the touch. In my experiments with the Froment process I always used oil in an amount between 60 and 120 lbs. per ton, which equals roughly from 3 to 6 per cent of the weight of the ore. In using such quantity of oil I acted entirely under Mr. Sulman's instructions. In experimenting with the Froment process I used the same oils as were used by Minerals Separation, Ltd., in their work on the Cattermole process. I have no idea of the speed of the beaters in my operation of the apparatus sent by Mr. Froment to Minerals Separation, Ltd., but the handle was turned from 30 to 35 revolutions per minute. I substituted the Gabbett for Froment's agitating apparatus in my later experiments because these Gabbetts were power-driven and I could treat smaller parcels of ores per test. All of my experiments with the Froment process were conducted on Broker Hill crude ore. That ore actually contained under one per cent of carbonate, but we added 10% of crushed calcite to the ore. In all my experiments when testing the Froment process I added 10% of calcite to the ore. I never varied this amount, but the method of mixing the calcite to

the ore was done in two ways. First the calcite was added to
402 the ore before treatment, and, second, the calcite was added to the settled paste, the production of which I have described in my direct examination.

The 60 or 70 lbs. of acid per ton of ore which was used at the Emu, Wales, plant was immediately consumed by the calcite in the agitating vessels, leaving, as I have said, no free acid in the spitzkasten. 70 lbs. of commercial sulphuric acid used in the treatment of the San Francisco del Oro ore contained about 50 to 56 lbs. of pure sulphuric acid, and the 60 lbs. contained about 43 to (359—282) 48 lbs. of pure sulphuric acid.

43 lbs. of pure sulphuric acid would generate 19 lbs. carbon dioxide gas, and 56 lbs. of pure sulphuric acid would generate 25 lbs. of carbon dioxide gas. At the temperature of the pulp at Emu, Wales, 65° to 70° Centigrade, the volume of 19 lbs. of carbon dioxide gas would be 209 cubic feet, and the volume of 25 lbs. of carbon dioxide gas would be 275 cubic feet.

From 209 to 275 cubic feet of carbon dioxide gas was generated in the mixtures at Emu, Wales, plant each time a ton of ore passed through the mixers.

In experimenting with the apparatus of the type shown in Figure 1 of the drawings of patent No. 793,808 for the purpose of investigating the Sulman & Picard Bubbles process, I operated upon tailings from the Cattermole process and never operated upon crude ore. My investigations were only in regard to the "clean-up" of Cattermole sands.

175 X Q. Then, I take it that you never used this ap-
403 paratus for the purpose of so agitating the pulp as to bring the oil into contact with the ore?

A. The apparatus being made of glass, it would have been impossible to violently rotate the worm without breaking the apparatus, and it should be understood that the mineral in these Cattermole tailings had already been oiled in the previous operation. The oil was already in contact with the sulphide mineral, and I had no occasion to use the apparatus as an agitator.

176 X Q. Did you ever see any apparatus of the type shown in Figure 1 of the drawings of patent 793,808 other than the glass structure to which you have referred?

A. That is the only one I have seen.

177 X Q. Did you see any other Froment apparatus besides (360—283) that which you have referred to in connection with your experiments?

A. The only Froment process I have seen other than those I have referred to in my experiments has been the application of this glass apparatus that we have just been discussing in the application of the Froment method.

179 X Q. About what is the range of the percentage of carbonate present in ores which you have successfully treated by the operations conducted by Minerals Separation, Limited?

A. In no case have I had samples that have been returned as giving more than .2 per cent of CO_2, except in the case of the San

Francisco del Oro ore, where the calcite was about 5% of
404 the total ore. In the Finnish-American and Saxbergets ore only traces of calcite existed, and no assay returns of CO_2 could be made on these samples.

In testing ores where calcite is present in the ore in large quantities I sometimes use acid salts instead of acid. The acid salts react with the carbonate, but they are cheaper than acid.

190 X Q. While in Australia, did you witness the operation of other flotation processes than the one operated by Minerals Separation, Limited?

A. The only plant that I was allowed to enter was the Gillies Sulphide Treatment Company's plant, situated on the block 10 property, and then I inspected this plant on receipt of instructions from Mr. C. F. Courtney, who asked me to report on the possibility of adapting this process to our method. The process being operated was the Potter process modified, a Gillies separating pan being used for the application of this rotation process. I was never allowed to enter the plants operating in other parts (361—284) of Broken Hill, although on several occasions I applied for permission.

191 X Q. What were these other plants which were operating to which you did not gain admittance?

A. The De Bavay Company, the Block 14 Potter process plant, the Elmore Vacuum Plant, situated at the Australian Metal Company's Works, and also the Elmore Vacuum plant, situated on the Zinc Corporation property, South Broken Hill. I did attempt to visit the Delprat plant on the Proprietary Mine as an ordi-
405 nary visitor, but my effort was fruitless. I could not gain admission when they identified me. At the time I was in Australia the Potter process plant was in operation. I am not sure whether the Delprat process was working at that time. Neither of the Elmore plants were running until Minerals Separation was carrying out the large scale trial for the Zinc Corporation. At that time a one unit Elmore test plant was conducting trials on the Zinc Corporation materials. The Elmore plant at South Broken Hill did not commence operation until some months after the agitation froth process was abandoned by the Zinc Corporation. The De Bavay process was working at this time on the plain water flotation. The Gillies plant started operations some considerable time after the agitation froth process was an established success. The Delprat plant on the Proprietary Mine was operating about the same time that the agitation froth process was going into full swing.

The buoyant effect of one cubic feet of carbon dioxide gas in water is, roughly, 62.4 lbs. and the buoyancy effect of the 275 cubic feet of carbon dioxide gas generated by the use of the maximum amount of sulphuric acid used at Emu, Wales, would be 275 times 62.4 lbs., provided the buoyant (362—285) factor of this volume of gas was applied at one time and on the same mass.

The condition of generation of CO_2 in the Emu plant could not under any circumstances be considered as gradual. The
406 production of CO_2 under the conditions of temperature, acid, violent agitation, is immediate, and is of the type

which I described to you in carrying out the attempted Froment test tube test. The evolution of CO_2 took place immediately the calcite came in contact with the acid solution, and therefore the production of CO_2 would only be sustained as long as the free acid remained and therefore the production would not be continuous.

199 X Q. I presume one of the purposes in adding the sulphuric acid in four installments was to spread out the evolution of CO_2 through the entire process rather than to concentrate it at one point. Is that correct?

A. The production of CO_2 never entered into our calculations at any time beyond the fact that we realized that under such conditions, a large consumption of sulphuric acid resulted. The object of the acid being added at these various stages was as follows: The acid in No. 1 mixer was to allow the oil to select the sulphide mineral without allowing oil contact to the calcite. The addition of acid to No. 3 was to cut out any gangue from the concentrate and allowing it to be thoroughly wetted so that it would remain with the residues. The acid addition in mixers No. 5 and 7 was for this reason only. It was never our intention to make use of the CO_2 produced for flotation purposes, for we realized that under the conditions of agitation, high temperature, acidulated solution, the
407 enormous volumes of air beating in and out of the pulp were quite sufficient to cause the almost complete loss of CO_2 (363—286) in the agitators and I can conceive no condition that would allow anything but an accidental small proportion of the gas produced in the agitators passing out with the pulp to the spitz boxes. If we wished to take advantage of this gas production for flotation purposes the most obvious thing would have been to add the acid in the spitz boxes where the nascent gas would then be liberated. As a matter of fact in the instance of the Emu plant this production of CO_2 per mixer, per minute, was only 0.6 cubic feet, and this quantity is exceedingly small when compared with the enormous quantity of air that would be beaten in by the very violent agitation.

The generation of carbon dioxide at Emu took place immediately the calcite came in contact with the acid.

As there were seven mixers altogether in the Emu plant, the production of carbon dioxide gas per minute in all seven mixers was 4.2 cubic feet of carbon dioxide per minute.

202 X Q. And the ratio of the volume of carbon dioxide gas generated per minute to the ore passing through the plant would be the same would it not, whether the ore passed through at the rate of a ton per hour or ten tons per hour?

A. I cannot agree with you here. It is a well-known fact in the operation of our processes that the bigger the tonnage operated upon
408 the more easy it is to effect economy of reagents. This is more particularly applied to sulphuric acid for I have known instances that have come directly under my own personal observation where the tonnage being treated has been doubled and the acid feed has remained unaltered in total quantity, and therefore per ton of ore the acid feed has been reduced by 50%. This altera-

tion of the acid feed being possible, you can understand (364—287) that no parallel can be drawn between the conditions of one ton an hour and ten tons an hour.

204 X Q. In the operation of the Emu plant did the 275 cubic feet of carbon dioxide that was evolved per ton of ore contribute materially to the production of the froth?

A. I consider that practically no production of froth resulted from the evolution of CO_2.

205 X Q. In other words you mean that under these conditions where 275 cubic feet of carbon dioxide were evolved per ton of ore, that still the production of the froth resulted from the air introduced during the agitation which was necessary to mix the oil with the mineral rather than from the carbon dioxide so evolved?

A. I consider that the beating in of air had many hundred times the influence in the assistance of froth production than that of the CO_2.

206 X Q. Did you ever make any determinations of the gases contained in the froth produced by the Emu plant?

A. No, I did not. My time was fully occupied in the production of concentrates. In any case I was quite satisfied that the
409 CO_2 played no important part in froth production.

207 X Q. This conclusion, so far as the Emu plant is concerned, is based upon your theoretical reasoning, is it not?

A. In coming to the conclusion that I did I combined common sense with theoretical reasoning, and I had only to look into one of our agitators to realize the enormous volumes of air that were being beaten into the pulp, compared with the comparatively small proportion of CO_2 being evolved, and I understood how impossible it is for any (365—288) large amount of CO_2 gas to remain in suspension under these conditions of acidulated liquor, high temperature and violent agitation.

It is quite possible under these conditions of violent agitation, where enormous quantities of air came into contact with all parts of the pulp, that the CO_2 would become very much diluted with the air and pass away with the excess.

We did not find it necessary to make any determination by analysis as to whether the froth forming the gas was air or carbon dioxide, because we were so sure that the froth was an air-produced froth that we did not give the matter any serious consideration.

212 X Q. But as a matter of fact it did not make any difference to you, as long as you obtained your concentrate, whether the gas in the froth was air or carbon dioxide?

A. Our first consideration would have been economy of
410 re-agents and we would certainly take every precaution to economize sulphuric acid, and under no circumstances whatever would we have considered the production of a CO_2 froth when we had the enormous reservoir of air, namely the atmosphere, to draw upon, when this air could be used for froth production merely at the cost of agitation.

The consumption of acid is a matter of vital importance and we would not wilfully consume this reagent for the production of CO_2

for froth-production. Although not intending to take advantage of the accidental presence of this very small proportion of CO_2, we could not prevent it.

The first consideration in obtaining practical results is the strict economy of reagents, and as I have explained before, if the consumption of sulphuric acid is high we can generally trace it to the presence of calcite in disturbing (366—289) quantities, and under these conditions we try to avoid the use of sulphuric acid and economize by using an acid salt. The consumption of this acid salt is much lower than the acid and the production of CO_2 correspondingly small. You will see therefore that we make every effort to keep the production of CO_2 down for the economy of acid and acid salt. Therefore we regard the evolution of CO_2 in our agitators as being one of our biggest difficulties and I have spent nearly ten years in experimenting to overcome this condition. After many years of research I have succeeded in my object and ores like San Francisco del Oro ores and other ores of calcite gangue are no longer
411 a trouble to us, for we have now overcome this difficulty of high acid consumption. Treatment of these ores can now be undertaken under much more economical conditions.

Our proposition was to produce the requisite percentage of the valuable minerals in a requisite state of purity under the most economical conditions, and as I have stated before, the last thing we wished was the production of carbon dioxide for reasons before explained.

217 X Q. All of the conditions of operation having been adjusted, as I assume they were at Emu, upon the most economical basis, and the question of economy having been thus disposed of, then you were willing to take the froth provided it contained the right amount of sufficiently pure mineral, and it was a matter of indifference as to what particular gas, carbon dioxide or air, was wholly or partially responsible for the formation of the froth. That is correct, is it not?

A. We were indifferent to this extent, that we knew that the gases causing the froth consisted of a very large proportion of air and accidental traces of CO_2. (367—290)

219 X Q. I am not asking you whether you knew how much air there was and how much carbon dioxide; I am asking you whether it made any difference, from a practical standpoint, how much there was of each of these gases, the conditions of operation having been fixed and settled upon the economical basis you have described?

412 A. We naturally had to take the froth as it was produced.

221 X Q. I presume the extended efforts which you have made, covering some ten years of time, to overcome the evolution of carbon dioxide, was caused by the fact that in operating the process in which Minerals Separation, Ltd., have been interested, carbon dioxide has been evolved in appreciable quantities in many instances. Am I right in this?

A. We never had been able to treat ores with calcitic gangue in disturbing quantities without a very large consumption of sulphuric acid, and my efforts have been directed in reducing this to a figure

that would be readily acceptable to any clients owning such mine ores.

In cold weather oleic acid becomes solid and if the temperature is not raised the oleic acid would never become disseminated through the agitated pulp.

232 X Q. In observing the operation of the agitators in the plant at Emu how are you enabled to tell that air is being beaten in and out again or to tell that the appearance you see is not caused by carbon dioxide as much as by air?

A. By looking into the mixers I notice that the beating or agitation of the pulp is very violent and I know that the peripheral speed of the outside of the four-armed agitator is over 1600 feet per minute. There are four arms traveling at this speed and the natural result of having (368—291) only two-inch clearance space from
413 the side of the square vat forming the agitating vessel is that the mixing with air is of a most violent type and wants to be seen to be fully appreciated. The type of agitation takes the form of beating against the sides and on occasions the center of the agitator can be discerned through the air space in the agitators.

223 X Q. What evidence is there upon observation of the apparatus such as that at Emu that air is beaten into the liquid and comes out again?

A. The agitation is of such a violent type that no other condition would be possible.

Redirect examination:

In my tests of the Froment process, the temperature was varied between normal atmospheric temperature and temperatures up to 28° or 30° Centigrade. The reason the steam coil was not used with the Froment apparatus was that we had no means of producing live steam in the laboratory.

The three-story plant which I have described was composed of three parts, one on each story, each of which was substantially the same as is shown in the drawing of patent 953,746 to T. J. Hoover.

242 R. D. Q. You have said that when you returned to the London Works from South Wales you saw Mr. Hyde, the defendant, at the London Works daily. Did you during this period, and before the departure of Mr. Hyde for the American Continent, participate in any tests of the large testing plant then at the London Works?

A. Yes. We conducted a test on Broken Hill tailings at
414 which Mr. Hyde was present for a portion of the time if not all. (369—292)

243 R. D. Q. In your testing work in the London plant, and in that of other men in your presence, was anything done at any time in regard to the retreatment of concentrates?

A. This has been common practice for several years. The object of retreatment, as I have explained before, was to increase the grade of the dirty concentrate produced in a primary operation where very high recoveries were obtained. Economy of re-agents

is sometimes made in this way and I have frequently carried out tests under these conditions.

244 R. D. Q. You have said that this has been common practice for several years but I wish you would be more specific and fix the date in relation to Mr. Hyde's presence at the Minerals Separation London Works in the Spring of 1910 and the Winter of 1910-1911.

A. Personally I was interested in this retreatment scheme before my departure to the Caucasus Mine in the Autumn of 1909. After my return from South Wales and since that date the method has been our common practice.

245 R. D. Q. If as a result of the retreatment of a concentrate, a residue is obtained which is comparatively rich in mineral, what is the proper metallurgical practice as to what is to be done with this residue?

A. These residues are considered as middlings and as such are mixed with the crude feed to the primary plant and re-
415 treated in this manner. (370—293)

Testimony for Complainants of Allen Crawford Howard.

LONDON, ENGLAND, August 27-28, 1912.

Direct examination:

I am twenty-nine years of age, a resident of Rockford, Essex, and am Works Manager of Minerals Separation, Ltd., one of the parties complainant. I was employed as Assistant Engineer to Minerals Separation, Ltd., from February 10th, 1908, to January 1st, 1910, when I was appointed Manager of their London Test Works, which position I still hold. My duties are to supervise the testing work on all ores received at the works, and to assist in the designing and erection of plan-s, and I am in control of the staff engaged at the works. I made the acquaintance of defendant in the latter part of February, 1910, at the office of Minerals Separation, Ltd., when he was introduced to me by Mr. T. J. Hoover as having joined the staff of the company.

Mr. Hyde was given a file of the Company's patents and other patents dealing with the flotation concentration of ores, together with a number of files containing reports of tests which had been made on ores submitted to the Company from time to time. He was engaged in the study of these, and discussed them with me from time to time. Defendant told me, on more than one occasion, that the work was entirely new to him and that he had
416 had no experience with the details of flotation work, and he asked me to assist by giving him all the information I could, as he anticipated that his stay in London during that visit would be of short duration. In accordance with Mr. Hoover's instructions, I took Mr. Hyde to our London testing (371—294) works, which were then at Charlotte Street, London, and I instructed every member of my staff that Mr. Hyde was to have free access to every part of the works; that any questions he asked were to be answered

to the best of their ability. I personally explained to Mr. Hyde the details of the construction of our large testing plant and I arranged for him to be instructed in the details of the process, first, by Mr. A. H. Higgins, who was at that time our senior metallurgist, and then I arranged for Mr. Hyde to share a room with Mr. E. W. Wilkinson, one of my assistants, who was engaged in carrying out small scale tests. I repeatedly inquired of Mr. Hyde whether he was getting all the information which he required, and he expressed himself entirely satisfied with the arrangements which I had made for his instruction in the theory and practice of the processes owned by my Company. Referring to the instructions which he had received from Mr. A. H. Higgins, Mr. Hyde informed me that he congratulated himself that he had sucked Mr. Higgins' brains dry.

The large scale plant at the London Works consisted of seven rectangular mixing compartments, together with three flotation
417 boxes, which were connected with the agitating or mixing boxes before referred to, by means of a flexible three-inch rubber pipe. (The witness then described the details of this last Charlotte Street plant, referring to the drawings "Complainants' Exhibit 1909 and 1910 Agitation Froth Plants.")

Mr. Hyde had the entire run of the works and I frequently explained in detail to Mr. Hyde the construction of this plant. On one occasion he was shown this plant in operation, and all three of the flotation boxes were continuously delivering to the concentrates vat a thick froth. (372—295) The ore treated was Broken Hill tailings and the plant was operated by Mr. G. A. Chapman. The drawing which I have referred to is a substantially correct representation of this large testing plant at the London Works which was exhibited to Mr. Hyde, as I have described. The drawing does not include the agitators, which consisted of four-bladed impellers, each blade being curved rearwardly.

As to the time required to produce a proficient test operator, in the case of the type of men we employ on this work, I have found that in from a fortnight to three weeks they are quite proficient in the work of testing ores submitted to us. The operation of our process is so exceedingly simple that proficiency is easily acquired within the limits of time mentioned.

I saw an apparatus identical with the apparatus marked for identification "Sulman and Picard Machine" early in February, 1910, at the laboratory of Messrs. Sulman and Picard.

418 Relative to the development or construction of apparatus of the type of this slide machine in the latter part of 1909, Mr. Theodore J. Hoover frequently discussed with me the possibility of designing a small scale testing apparatus which would enable our operators to turn out more work in a given time than they were able to do with the apparatus then in use. We discussed several possibilities early in February, 1910. Mr. Hoover informed me that Messrs. Sulman and Picard, our consulting metallurgists, had installed at their laboratory a new type of testing machine which was an immense improvement on anything which he and I had so far thought out. He briefly outlined the construction to me. This was

the apparatus marked for identification "Sulman & Picard Slide Machine." He at once set about the preparation (373—296) of plans and details of a machine embodying the principle of this machine and discussed with me the material from which it should be made and its dimensions. He instructed me to find out from Mr. Higgins the exact sectional area of the rectangular testing Gabbett then in use, and to measure the depth of the normal charge of ore and water inserted in the machine, and note the depth of the under surface of the froth formed in making the test. This I did and from the information supplied by me, Mr. Hoover himself drew out a complete plan for the construction of the slide machine. About the date of the completion of this plan, Mr. Hyde arrived in London and shortly afterwards Mr. Hoover instructed me to take this
419 plan to W. H. Dearden & Co. and explain the construction to them with a view to their quoting us for the manufacture of a machine. I was very busy at the time and Mr. Hoover said that, provided I explained the details to the maker, I could leave Mr. Hyde to follow the matter up. Mr. Hyde himself visited another firm of engineers and arranged for a second machine to be made. I had no part in the ordering or manufacture of this second machine, which proved quite unsatisfactory, and no further orders were placed with this firm. I may add that Mr. Hyde went with me to W. H. Dearden & Co. and was present when I explained the machine and that the machine which was made by W. H. Dearden & Co. was a satisfactory machine, although sundry minor improvements were introduced in subsequent machines. When the slide machine was delivered at the Works, I instructed Mr. Hyde and Mr. Wilkinson to test its possibilities. I recollect that at the end of their first morning's work they had not been able to produce any flotation and were unable to account for this. On a careful examination of the machine, I found that the maker had fastened down (374—297) the rubber sheet with some form of glue, and I knew that any trace of glue would be sufficient to prevent flotation. On removing the rubber sheet and cleaning it and the machine from all traces of glue, it was found, on starting up the machine again, that an excellent froth was produced, and from that time onwards the operation on the machine presented no difficulty.

I now produce the test machine which was the immediate
420 predecessor of the slide machine.

The apparatus produced by the witness is put in evidence as "Complainants' Exhibit Square Test Apparatus."

This machine was used by Mr. Higgins in his small scale experimental work. It consists of a rectangular agitating vessel, the bottom and two of its sides being of wood and the remaining two sides of glass. The ordinary spindle, provided with a cross-blade agitator, was suspended from the motor placed above the machine, enabling a violent agitation of the contents to be effected. In connection with this apparatus two small spitzkasten were used in series. This apparatus is properly described in the testimony by the defendant, Mr. Hyde, but the defendant is incorrect in his statement that the

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oiled mineral matter floated off as a surface film. In the proper operation of this apparatus, and as I have repeatedly seen it operated, the concentrates are discharged or float off in the form of a coherent froth.

At the end of the year 1909 I suggested to Mr. Hoover that we insert a sliding door on one side of this square test apparatus to draw o[illegible]e froth. Such a machine was made and I now produce it. It [illegible]ot work satisfactorily and, after careful trial of its possibilities, its use was (375—298) abandoned.

The following testimony of the defendant is untrue:

"Together we designed a machine similar to and probably the same as the machine referred to as the slide test machine by
421 Dr. Chandler and Mr. Nutter in their testimony. I had several of these machines built in London and remained in the city long enough to develop a system of tests by the use of this apparatus and to instruct Mr. Wilkinson, an attache of Minerals Separation, in the use of this apparatus."

(The following testimony of the defendant, the "we" being Mr. T. J. Hoover and Mr. Hyde, was read to the witness):

"We discussed the matter together, making several sketches, details of each being contributed by each of us, and finally decided upon the form which was finally constructed. Such computations as to size as were necessary were made by me.

"The machine as originally designed was constructed under my supervision, was tested by me and was modified under my supervision in a number of minor features after the first tests were made."

The first paragraph quoted is untrue to this extent, that the machine embodying the principle of the slide machine was already in existence, that the plan for the machine made by W. H. Dearden & Co. was completed before Mr. Hyde arrived at our London office, and that such computations as to size as were necessary were not made by Mr. Hyde, but were made by Mr. Higgins and myself and communicated by me to Mr. Hoover.

As to the second quoted paragraph, the facts are as I have
422 stated. Mr. Hyde probably did something as to minor alterations to the apparatus after the first tests were made.

During Mr. Hyde's absence in Mexico, United States and Canada, he sent home a large number of samples of ores and metal products to be tested. He also brought with him some samples to be tested. The samples sent by him were tested by Mr. A. H. Higgins and the tests were reported to (376—299) me, and the reports were handed by me to Mr. Hoover or to the secretary of the Company, Mr. A. O. Williams. After Mr. Hyde's return, he was constantly in the Works and discussed with Mr. Higgins, Mr. Nutter and myself, the results of the tests carried out in his absence, and he personally supervised the testing of the samples which he brought with him. As an example of one of these tests involving retreatment, I refer to a report on the testing of a sample of Tecolotes slime products by Mr. A. H. Higgins, dated January 4, 1911, which I now produce. This report was handed to me by Mr. Higgins and before sending

it into the office of the company I showed it to Mr. Hyde, who read it, and discussed it with Mr. Higgins and myself. I believe that there are other references to the retreatment of concentrates in Mr. Higgins' reports of the testimony of Mr. Hyde's specimens, but I have selected this as an example.

The report produced by the witness is put in evidence as "Complainants' Exhibit Higgins' Report January 4, 1911." The
423 particulars of assays annexed to the report are produced for inspection, but not offered in evidence.

(The witness describes the large scale testing apparatus in use at the London Works of Minerals Separation, Limited, when Mr. Hyde returned to London in December, 1910, identified herein as the King John's Court Standard Plant.)

At these works in King John's Court, there was also another plant which was nearing completion at the time of Mr. Hyde's return to London and which was completed within the following week. This plant is shown in the drawings of British patent No. 23,949 of October 15, 1910, to Edward H. Nutter, and Theodore J. Hoover and Minerals Separation, Limited. This plant was designed with the object of removing (377—300) a low-grade concentrate which could afterwards be delivered to the Standard Plant for the purpose of obtaining a high-grade concentrate by retreatment. The idea was that in the first plant a practically complete recovery of the mineral values would be obtained, and that in the subsequent treatment the concentrate would be raised in grade to a saleable value. This appearance was known as the Differential Plant and a large number of tests of this apparatus were made in the presence of Mr. Hyde during the first half of January, 1911. I frequently discussed with Mr. Nutter and Mr. Hyde the principle of this plant and the advantage of aiming in the first treatment of ores at a high recovery and then raising the grade of the concentrates by retreatment.

This was an accepted mode of treatment at the works and
424 this apparatus was designed to carry it out, in connection with other points. The subject of retreatment was first discussed by me with Mr. Hoover and Mr. Chapman in October, 1909, but did not then appear to be new to Mr. Chapman. Afterwards it was part of our established practice at the works, and when I took up my duties as Works manager it was already established, and has continued to the present day. I have assisted in planning, in all, three commercial plants for retreatment, these plants being the Braden plant, the Saxbergets plant, and the Cuba Copper Company's plant. Retreatment tests have been of frequent occurrence certainly since January 1, 1910.

The King John's Court Standard Plant was operated in the presence of Mr. Hyde on at least one occasion, on January 5, 1911, when we were treating a mixed copper-zinc ore. The ore floated readily and all five boxes were continuously discharging a thick coherent froth. I fix the (378—301) date of this occurrence by the fact that on this and the preceding and succeeding days some samples of a cobalt-nickel ore, brought by Mr. Hyde to the Works,

were being tested under his direct personal supervision, and that he was called down from upstairs when we were ready to run the plant, to witness the run. My Works' daily report for that day identified the test.

I now produce one of the two spitzkasten referred to by me as used in connection with "Complainants' Exhibit Square Test
425 Apparatus." The other one was sent to New York prior to the commencement of the testimony and is in the possession of Dr. Charles F. Chandler.

The apparatus produced by the witness is put in evidence as "Complainants' Exhibit Spitzkasten Square Test Apparatus."

(The witness produces three sheets of drawings as representing the large scale test apparatus in use in the London Works of Minerals Separation, Limited, when Mr. Hyde returned to London in December, 1910, and describes them.)

The drawings are put in evidence as "Complainants' Exhibit King John's Court Standard Plant."

I have made a search for drawings of the slide machine. I have not been able to find the original pencil drawing made by Mr. Hoover, but I have found the original tracing which was made from that drawing.

I was supervising the draftsman who was making this tracing when Mr. Hoover called me into his office to introduce Mr. Hyde to me on the occasion of Mr. Hyde's first visit to our London office.

The drawing is put in evidence as "Complainants' (379—302) Exhibit First Tracing Slide Machine."

This occurred on Monday, February 14, 1910. I fix this date by a cable message announcing Mr. Hyde's departure from New York for London, as well as by other circumstances. This cable message is dated February 5, 1910, and is as follows:

426 "Will sail on February 5, intend to stop at Hotel St. Ermins.

JAMES HYDE."

It is stipulated that if Giovanni Battista Zanardo were called as a witness he would testify that he received from Alcide Froment, the communicator named in the British patent No. 12,778 of 1902, the documents marked for identification "Froment Description" and the drawings marked for identification as "Froment Plan" and "Froment Drawing A," and forwarded the same to Mr. John Ballot, the present Chairman of Minerals Separation, Limited, one of the complainants, during the latter part of December, 1903, and that this stipulation shall have the same force and effect as the deposition of this witness, taken under the present commission, the right of cross-examination being waived. (380—303)

Testimony for Complainants of William Henry Ballantyne.

LONDON, ENGLAND, Aug. 28—Sept. 4, 1912.

Direct examination:

I am thirty-one years of age and a resident of London and a Chartered Patent Agent and consulting Chemist and Engineer. I received my first technical education in Allan Glen's Technical School, Glasgow, where I studied engineering and chemistry. Subsequently I proceeded to the University of Glasgow and studied engineering, chemistry and metallurgy. I took the degree of Bachelor of Science. For some time I was engaged in prac-
427 tical engineering with a firm occupied chiefly in the manufacture of crushing machinery, centrifugal machines and the like. In 1900 I joined the firm of Boult, Wade & Tennant, Chartered Patent Agents, as a technical assistant, and continued my study of engineering, chemistry and metallurgy, taking up two special college courses of metallurgy in London. From 1900 to the end of 1905 I worked as a technical assistant to Messrs. Boult, Wade & Tennant, devoting the majority of my time to metallurgical work. In 1905 I became a Chartered Patent Agent, and in 1906 became a member of the firm of Boult, Wade & Tennant. Since that date my work has continued to be largely on metallurgical subjects. I am a member of various scientific bodies, including the "Chemical Society" and the "Society of Chemical Industry," and I have a private laboratory where I do experimental work. In my own practice I have acted for a large number of inventors of processes for the treatment of ores, and I have come into contact almost daily with the many processes which have been proposed both for concentrating and smelting ores. (381—304)

I first studied the subject of ore concentration by oil in July, 1902, in connection with clients who proposed to operate a process of the bulk oil flotation type, that is to say, a process in which metallic sulphides are floated in water by a body of viscous oil and by virtue of the buoyancy of the oil. In this connection I closely examined the Elmore patents, the Robson & Crowder patent,
428 and various other earlier patents. When I joined my firm in 1900 they had already been acting for Mr. Sulman for many years and since that date I have constantly acted for Messrs. Sulman and Picard and for a number of their clients and associates. I have advised them constantly on processes relating to the concentration of ores by oil, and have very frequently been present at their investigations and have personally conducted tests in conjunction with them and their associates and assistants. I first met Arthur Edward Cattermole early in November, 1902, and upon his instructions obtained provisional protection in Great Britain for his processes. This was before Mr. Cattermole had come into contact with Mr. Ballot.

I first met Mr. Ballot in the latter part of 1902, when he took up a process of treating gold ores which was then being investigated

by Messrs. Sulman and Picard. In December, 1902, I was informed that Mr. Ballot and others proposed to take up the Cattermole process with the object of forming a company to exploit it, and from December, 1902, up to the present time I have been in constant touch with Messrs. Sulman, Picard and Ballot and their assistants in the investigation and exploitation of processes for the concentration of ores, and I have acted as their adviser on matters relating to patents, and have prepared their patent specifications. I have acted as expert in a number (382—305) of patent suits in England and other countries on the subject of ore concen-
429 tration by oil. I have also acted in a similar capacity in proceedings before the Patent Offices of various countries. Indeed I may say that a great part of my time every month during the past ten years has been occupied with these matters.

I first saw the Elmore bulk oil flotation process tested in the latter part of 1902 and I have many times since then tried the Elmore processes under different conditions and with different ores. These processes are set forth in United States Patents Nos. 676,679 and 689,070, the latter differing from the earlier one only in that it describes the use of an acidified ore pulp as distinguished from a neutral ore pulp described in the earlier patent. It is essential to these processes that the oil should be thick and viscous. I have frequently tried thin oils, such as oleic acid, in the Elmore processes, but they do not operate, as the viscosity of the oil is not sufficient to retain or entrap the metalliferous sulphides, which easily fall out of the oil. It is also essential for the same reason that the Elmore processes shall be carried out in the cold, because if the oil is heated it becomes thin and will not entrap nor float the sulphide mineral. In the tests of the Elmore processes it was always essential that the mingling of the pulp and the oil should be as gentle as possible, so as to avoid the inclusion of globules of water in the oil, and to avoid breaking up the oil into globules, because when the oil included water or when the oil was broken up, gangue was floated with the oil. I have tested the Elmore process, using vigorous agita-
430 tion, and the whole pulp was brought into an emulsion like mayonnaise, full of ore, and this emulsion would not separate, after standing for months. (383—306)

9 Q. Please now give consideration to such processes of ore concentration wherein the preference of oil for metallic matter was utilized, as were to some extent successful in practice up to April 12th, 1905, the date of the filing of the Provisional Specification of British Patent No. 7803 of 1905, this being the British patent corresponding to the patent in suit.

A. I have carefully investigated everything that was done in practice in the concentration of ores by oil and it has been part of my business to know what processes were tried in practice. The first process which gave sufficient indications of practical value to justify the use in practice was the Elmore bulk oil process, referred to in my answers to the last three questions. This process was to some extent successful in practice, but the technical literature showed that

the Elmore process had been abandoned by 1905 and as I have stated the process has not been heard of in practice for many years.

The next process of ore concentration by the use of oil which was to any extent successful in practice was the Cattermole process. I first saw tests of this process carried out by Mr. Cattermole in small bottles at the end of 1902. From that time onwards Messrs. Sulman, Picard & Ballot, with various assistants, were engaged for
431 about two and a half years experimenting with the Cattermole process described in the United States Patent No. 777,273, and exploiting the invention. Briefly stated, the process is as follows: Finely crushed ore containing sulphide minerals is mixed with four times its weight of water (generally acidified) and to this is added a small quantity of oil or oily emulsion, the proportion of oil varying from 45 lbs. per ton of ore to 70 lbs. per ton or more in certain cases. (384—307) The mixture was agitated, first in a very violent manner so as to bring the oil into intimate contact with the sulphide particles. At this stage the oiled sulphides have agglomerated together into small flocculent masses called "flocks." Thereafter the mixture was subjected to a rolling form of agitation to cause the agglomerates to form into shotty granules. When the pulp was introduced into an upcast separator, the granules being of great weight in relation to their area, had the power of falling readily through water, while the gangue was carried away upwards by the up-current of water, because the falling power of the gangue was not so great. The process was worked out with the greatest care and ingenuity by Messrs. Sulman, Picard & Ballot. These gentlemen erected in London a plant which has been referred to in this case as the Australian Cattermole Plant, and I frequently saw this plant in operation. To a scientific man the process was extremely interesting and the agglomeration of the sulphide particles into granules is a remarkable phenomenon. My clients informed me at
432 various times in 1904 and 1905 that the process gave a great deal of trouble to the practical and that the consumption of oil was prohibitive on the large scale. The Cattermole process was therefore abandoned in practice.

With the exception of the Elmore process and the Cattermole process, no process of ore concentration by the use of oil had been successfully used in practice up to April 12th, 1905, so far as I have been able to determine by careful and exhaustive investigation.

10 Q. Please now relate the facts within your knowledge which led to, and culminated in, the invention of the patent in suit. (385—308)

A. As I have stated, from the end of 1902, onwards I have been in constant touch with Messrs. Sulman, Picard and Ballot. Mr. Ballot's office is at 62 London Wall, London, E. C.; the laboratory of Messrs. Sulman and Picard is at 44 London Wall, E. C.; and it has been my practice to attend in London Wall frequently, on an average twice a week, for the past ten years. I have also attended very frequently at the various laboratories in which these gentlemen worked, including the various laboratories or test works of Messrs. Minerals Separation Limited. The story of the origin of the agita-

tion-froth process constituting the invention of the patent in suit, is a story of untiring zeal and industry and scientific ingenuity on the part of Messrs. Sulman, Picard and Ballot. I have had the fullest possible opportunity of seeing the work of Messrs. Sul-
433 man, Picard and Ballot and I have always had the highest admiration for the manner in which, in spite of endless difficulties, they worked out the process of ore concentration by oil until their efforts were successful, and they produced the agitation froth process, which is in my opinion the greatest invention in the mineral industry in our times. The details of the origin of the invention, within my knowledge, are as follows: The efforts of Messrs. Sulman, Picard and Ballot from December, 1902, to the early part of 1905 were mainly directed to the perfection and thorough investigation of the Cattermole granulation process, but as scientific men they never shut their eyes to the possibilities of developments of ore concentration processes along similar lines to that in which they were working. Messrs. Sulman, Picard and Ballot used to confer daily on their investigations and they jointly introduced a number of modifications into the Cattermole process. In the first place (386—309) they introduced the Gabbett or cone mixer which was at that time a well-known metallurgical appliance for giving a violent agitation to a liquid, or pulp, and this device was used in the Cattermole process in practice.

After trying a number of different oil emulsions and straight oils, they found that the best oil for the purpose was oleic acid, and they, therefore, carried out their later investigations with oleic acid. Messrs. Sulman, Picard and Ballot frequently discussed with
434 me the effect of heat in the Cattermole process, and during the years 1903, 1904 and 1905 the mixing of the pulp and oil was tried by them at various temperatures. Messrs. Sulman, Picard and Ballot made various other modifications in the Cattermole process.

As I have stated, there were various difficulties which arose in the investigations above referred to. Messrs. Sulman, Picard and Ballot used to refer to those as "loose end observations," and they drew my attention to them because it was their practice to keep me fully informed of all developments. In particular, I remember that on various occasions in 1903, and also in 1904, they pointed out to me an accidental flotation which they obtained in one of the upcast separators of the Cattermole apparatus when the cnditions were abnormal in some way not then understood. This accidental float consisted of loose flocculent masses of partially granulated sulphides, which, instead of sinking with the granules in the ordinary way, came to the surface of the upcast separator owing to air attachments. The amount of this accidental float, so far as I am aware, never exceeded one or two per cent of the total concentrate, but it was sufficient to puzzle Messrs. Sulman, Picard and Ballot, who on several occasions asked my advice about it, because they expressed the view that this loose end observation should be further investigated and that it might be (387—310) made its own remedy, and they wished me to

see that the process or processes which they investigated were
435 at all times properly protected by patents. Again, at various times during these years, 1903 and 1904, they pointed out to me that the degree of crushing of the ore was an important factor, particularly in practice, and it was one of the objects of the work of Messrs. Sulman, Picard and Ballot to solve the problem of successfully treating slimes, that is to say, finely crushed ore, which is so fine that it will not readily settle in water. Almost from the start another aim which Sulman, Picard and Ballot expressed to me was the reduction of the quantity of oil to be used in the Cattermole process. At the beginning of January, 1905, Messrs. Sulman & Picard informed me that they had been appointed by Messrs. Minerals Separation Ltd. to take full technical control of the experimental work of that company and to take the technical control of the test works at Aldermanbury Avenue. They expressed themselves as very pleased because they were anxious to work out to finality the process of ore concentration by the use of small quantities of oil. Mr. Ballot was then, as now, the Managing Director of Minerals Separation Limited, and during the first three or four months of 1905 investigations and discussions were taking place practically every day between Messrs. Sulman, Picard and Ballot and myself. In or about the first week of February, 1905, at a conference at 62 London Wall, these gentlemen informed me that they had decided to get to the bottom of their loose-end observations, and for that purpose they had decided to investigate and quantify all the factors con-
436 nected with the Cattermole granulation process. They informed me that they had drawn up a series of tests which they were proceeding to carry out, and they intended (388—311) to have the results all plotted in curves, and we discussed the method of indicating the results. I particularly remember these gentlemen informing me at this time that they intended to reduce the proportion of oil to a vanishing point, indeed, I believe these very words were used. At the end of February, 1905, Sulman, Picard and Ballot devised the process described in the British Patent No. 5260 of 1905, a process in which no oil is used at all, and I remember saying to them at that time (February, 1905), "you have indeed reduced the quantity of oil to a vanishing point." I only mention this to fix the dates, as this patent to which I have referred had nothing to do with the investigations of the various factors of the Cattermole process.

From the 8th of March, 1905, to the 15th of March, 1905, I saw Messrs. Sulman, Picard and Ballot nearly every day. On one of these days, I cannot fix the actual date, they informed me of their startling discovery of the agitation-froth process. To the best of my recollection, Mr. Ballot went out of town for some days thereafter, and it was not until the 31st of March, 1905, that we got together again and fully discussed the protection of the invention of the Patent in Suit. One of the first days of April, 1905, I attended at the Aldermanbury Avenue Works with Messrs. Sulman, Picard
437 and Ballot, and they demonstrated their process to me. Broken Hill Tailings crushed to 60 to 90 mesh were mixed with slightly acidified water and introduced into the ordinary Gab-

bett of the Cattermole test plant. 0.1 per cent of oleic acid was added, and the whole pulp was heated to a temperature between 30 to 40° Centigrade. After violent agitation in such a way as to introduce air into the pulp, the agitation lasting for several (389—312) minutes, the pulp was brought to rest and immediately a coherent and persistent froth rose to the surface. Although I was very closely familiar with all the earlier processes of ore concentration in which oil had been used, including all the prior patents which have been mentioned in this suit, the production of this agitation-froth was to me little short of a miracle. I had never seen anything of the sort before, and I recognized that Messrs. Sulman, Picard and Ballot had at last reached success in their investigations and had devised a process which would economically and successfully concentrate ores.

Summing up the above, Messrs. Sulman, Picard and Ballot first installed the cone mixer and started working along the lines of violent agitation from an early date in 1903. Secondly, they found it most advantageous to use oleic acid in their investigations. Thirdly, they found that the heating of the pulp had an influence upon the oiling of the metalliferous matter and that led them to experiment with heated pulps when going into details of their final tests. Fourthly, they determined to experiment
438 with finely crushed ore containing a high proportion of slimes and they did so. Fifthly, they determined to reduce the quantity of oil to a vanishing point and to do it step by step so as to ascertain the results obtainable throughout the range of reduction, in each case using the slimy pulp, the violent agitation, and various degrees of temperature; and using also a pulp acidified to the extent to which they were accustomed in their previous investigations.

I have seen the agitation-froth process carried out many hundreds of times. I have also seen investigations of the process making wide variations step by step in the factors which I have referred to above, and I have myself, on (390—313) many occasions, carried out these investigations and I now know that if the instructions which Messrs. Sulman, Picard and Ballot drew up in February, 1905, are carried out, namely, to use a slimy pulp, acidified with say .5 per cent. of sulphuric acid, to heat the pulp say to 30° Centigrade and then to agitate it violently with proportions of oil beginning at 50 lbs. of oil per ton of ore and repeating this test, reducing the quantity of oil step by step down to the vanishing point, it is inevitable that the agitation-froth shall be produced when the quantity of oil is diminished to the limits set forth in the Patent in Suit, and that a particularly good froth and efficient concentration is obtained when the proportion of oil is about 0.1 per cent on the ore, the percentage recommended in the patent in suit as being suitable and economical. I also know that the oil selected by Messrs. Sulman,
439 Picard and Ballot, namely, oleic acid, is one of the best and in most cases the best oil that can be used for carrying out the agitation-froth process.

Sulman, Picard and Ballot, in the later days of April, 1905, and at the beginning of May, 1905, proceeded at once and with consid-

erable energy to reduce their invention to practice, and they continued their daily conferences at which I was frequently present. In the first week of April, they informed me that they had devised a method of making their process continuous and that they were fitting up a spitzkasten so that they could run out the agitated pulp from their cone mixer into the spitzkasten continuously and get the froth separated continuously by overflow from the spitzkasten. On several occasions at the beginning of May, 1905, I saw the process working in this way. The pulp after agitation as described in the Patent in Suit, was run out into the spitzkasten over a short launder, and when (391—314) the pulp reached the comparatively still water in the spitzkasten, one thick, coherent and persistent froth rose to the surface and flowed over the lip of the spitzkasten. The process in all its essential particulars, and this separation of the characteristic agitation froth, have remained the same to the present day, and very few weeks have passed during the past seven years in which I have not seen the process carried out in exactly this way.

11 Q. Please now relate the facts within your knowledge as to the preparation of the patent applications in Great Britain,
440 United States, and other countries for the invention set forth in the Patent in Suit?

A. On the first Sunday in April, 1905, I made at home a rough draft in pencil of a provisional specification upon the invention of the patent in suit. I had it typed out the following day and took it down to Messrs. Sulman, Picard and Ballot, and we discussed it, various additions and alterations being made during our conference. There were various re-drafts of the specification which went to and fro between Messrs. Sulman, Picard and Ballot, and my firm in the early days of April, 1905, and on the 12th of April, 1905, the application for a British Patent was lodged accompanied by the provisional specification. Upon the first of May, 1905, or thereabouts, Messrs. Sulman, Picard and Ballot, instructed me to prepare a complete specification and drawings for filing in the United States and other foreign countries. I again proceeded to Aldermanbury Avenue Test Works with my firm's chief draughtsman, Mr. G. C. Walker, who took sketches of the apparatus. Mr. Sulman supplied me with a rough sketch or diagram of the complete apparatus similar to the diagram referred to in this case as "Sulman Drawing accompanying Report May 3, 1905." I (302—315) then proceeded to draft the complete specification with reference to the drawings prepared by Mr. Walker and I also prepared claims for the United States and other foreign patent applications. These
441 were again discussed in detail with Messrs. Sulman, Picard and Ballot, and when the American papers were completed my firm despatched them to the United States on the 20th of May, 1905.

At the demonstration of the agitation froth process occurring on one of the first days of April and attended by me, the three inventors, Messrs. Sulman, Picard and Ballot, and Mr. Arthur Howard Higgins and others were present. The object of my visit was to obtain the necessary particulars for the patent applications, and the patenting of

the invention was discussed fully in the presence of all. A part of the information supplied to me for the preparation of the patent applications was the two reports of Mr. Higgins, which have been marked for identification "Higgins' Report March 2, 1905" and "Higgins' Report March 16, 1905."

In the apparatus employed for this demonstration, the agitation vessels contained baffles each consisting of three loops of wire depending from a ring of wire. This ring was slipped over the top of the cylindrical glass vessel so that the loops of wire tipped down into the pulp at the sides of the rotating cone. These baffles are not shown in Figure 1 of the patent in suit.

18 Q. How do you account for the fact that they are not shown in Figure 1 of the Patent in Suit?

A. Figure 1 of the Patent in Suit is merely a diagram illustrative of the type of apparatus suitable for carrying out the invention. At the time when my firm's draughtsman made his sketch the
442 apparatus was not in use and the baffles were not placed in position. When I saw the drawing prepared (393—316) for the specification I made no alteration on it because it was a mere diagram and because the indication of a vessel with a cone rotatable on a vertical axis in the vessel was a sufficient indication to a metallurgist that a Gabbett or cone mixer was to be used. I notice that the drawings which I employed in the Cattermole specifications embodied the same convention as does also the "Sulman Drawing Accompanying Report May 3, 1905." Indeed I state as a fact that in the years 1900 to 1905 it was common to indicate a Gabbett or cone mixer by a sketch of a vessel with a cone in it. I also point out that Figure 1 of the Patent in Suit is a mere diagram in every other respect. The pump R is of the conventional form generally introduced in patent drawings. I have never seen such a pump in use in the agitation-froth plant. Again the swan-neck pipe H is bent round in such a way as to make the diagram fit into a single sheet of U. S. Patent Office drawing paper. As a matter of fact in the actual apparatus the pulp passed straight on from a short swan-neck pipe to the spitzkasten somewhat as shown in the "Sulman Drawing Accompanying Report May 3, 1905." Again, there were three mixers in the actual plant but we did not have room for three in the diagram. Again, we had no room in the diagram for the shaking table and in other respects the diagram does not give a picture of the actual apparatus. In my opinion the process
443 is so simple that a metallurgist requires no drawing to enable him to carry the process into effect, but I inserted a diagram in the complete specifications describing the agitation froth process as I think that a diagram assists the reader in appreciating the invention.

The diagram Fig. 1 of the patent in suit was used in the applications for patents in some twenty-five countries (394—317) in different parts of the world in addition to that in the United States, all for the invention of the patent in suit.

20 Q. Does the word "Gabbett" appear in any of the specifications filed in any of the Patent Offices, and have you recently refreshed

your recollections as to this point by an examination of the public record thereof, and what does this public record show and what are the particulars relative to this fact?

A. I have refreshed my memory on this point recently by examining the original provisional specification filed at the British Patent Office, but I also recollect the circumstances clearly. In the specification which I originally prepared and filed in Great Britain I described the mixers as "Gabbett mixers." The provisional specification was examined in April, 1905, by Mr. Examiner Graves, who is now the Commissioner of Patents for the Empire of India. Mr. Graves was a metallurgist. He pointed out to me that the word "Gabbett" being the name of a patentee ought not properly to be used in a British Patent specification, and he asked me to alter the term "Gabbett mixer" to the equivalent well-known term "cone
444 mixer." Mr. Graves' proposal was obviously sensible and I adopted it. The body of the specification for the United States Application and those in other foreign countries was largely copied from the British Patent specification.

21 Q. Referring now to Figure 2 of the Patent in Suit please state whether or not in the cone mixer there shown there is an illustration of an effective baffle.

A. There were in the Minerals Separation laboratory several mixers of the type shown in Figure 2 of the patent in suit. The discharge-conduit *a'* provided an effective baffle, and the usual removable wire baffles were dispensed (395—318) with when this type of mixer was employed.

22 Q. Please now give consideration to such proposed processes of ore concentration by oil as were described in Patents or other publications prior to April 12, 1905, and known to you, and which were not included in your answer to 9 Q., which was limited to those processes which have been utilized to some extent in the art.

A. Mr. Ballot called my attention some six years ago to a curious passage in Herodotus in which a wonderful story was told of the virgins in a strange and mythical island, who smeared pitch on feathers and rubbed the feathers in the sand at the bottom of a lake whereby particles of gold in the sand stuck to the pitch and were thus collected.

In the year 1903 I made an exhaustive investigation of
445 the whole subject of ore concentration with the object of tracing any references on paper to the use of oil in ore concentration, and I dug up from obscurity a number of documents, many of which have been referred to in this case. The first of these was the British patent of Haynes No. 488 dated 23d February, 1860. This describes a process for obtaining metals from their ores, which consists in mixing the ore (ground to 100 mesh) with oily or fatty matter and bituminous or tarry matter so as to form an admixture of the agent and the ore. The admixture which is in the form of a stiff paste is then kneaded in water with the object of washing out the gangue. I have frequently tried to work this process and unquestionably some gangue can be washed out of the pasty mass, but any such process is entirely impracticable, and the process never

could have been of any use, but it is an interesting scientific curiosity.

The next patent specification which contains proposals for the treatment of ores by the use of oil is the United (396—319) States Patent of Everson No. 348,157 of 1886. Two processes are described and I have frequently experimented with both of these processes. Everson's processes are of the same type as the Haynes' process, that is to say the powdered ore in a dry state is made into a paste or mud with oil or fatty matter and thereafter this paste is kneaded under water with the object of washing out the gangue. Everson's process differs from Haynes' process in that the water is acidified, for example to the extent of one or two fluid
446 drachms of acid to one gallon of water, i. e., rather less than 0.2 per cent. on the water. The first process described in Everson's specification is so complicated that it can be set aside because no one would ever think of carrying it out in practice. Referring to the second process, which is described in the patent specification No. 348,157 from page 2, line 75, to page 3, line 64, the powdered ore is mixed with petroleum or paraffin oil. The proportion is defined in two ways: first as three fluid drachms of oil to two ounces of ore. Three fluid drachms equal 180 grains. Two ounces of ore equals 900 grains. Therefore the proportion of oil to ore is 20 per cent. Again the proportion is stated to be a barrel of oil to the ton of ore. An American barrel in 1885 was, I am informed, 500 lbs., while a ton was 2,000 lbs., so that the proportion of oil to ore is 25 per cent. In testing the Everson process I mixed the powdered ore with the oil thoroughly; I then placed the mass in water acidified as above stated. I then agitated the mass so as to detach the sand as far as possible and attempted to remove the concentrate by means of a constant overflow of water from a washing-out vessel. Sometimes I got practically nothing to overflow, but in many cases I succeeded in getting the (397—320) oil with some sulphides in it to flow off with the water overflow. Everson found, as is the fact in many cases, that the sand is heavier than the mixture of mineral and oil and I have seen cases in which the oil floated quite a fair proportion of the sulphide minerals
447 in the vessel used for washing out. This process like the process of Haynes is curious and interesting to a scientist. I am certain that the process could not be carried out in practice with any measure of success, and the specification is only of importance as showing the origin of the remarkable fact that acidified water has a greater wetting power for gangue than neutral water.

The next patent specification relating to a process of concentrating ores in which oil is mentioned is the United States patent of Hebron and Everson No. 471,174 dated 22d March, 1892. I have never attempted to carry out the proposals contained in this document. It is suggested that buoyant material such as bark, moss, straw, cotton-wool, soap, and so forth, shall be "pressed into the cavities and pores of the mineral particles" so that they (the joined mineral and metallic particles of the ore and buoyant material) are

of less specific gravity for the time than the rock particles of such ore. Bearing in mind the nature of a powdered ore this suggestion is perfectly absurd. No intelligible process is described in the patent specification.

Another patent specification relating to the same proposal is United States Patent of Hebron 474,829, dated May 17, 1892. This process is stated to be "an improvement on the process heretofore invented by Carrie J. Everson and myself jointly" followed by a specific reference to the application for the patent which I have just described. This specification describes an apparatus and a
448 process and (398—321) is characterized by the fact that there is no reference to the use of oil or soap whatsoever, but the buoyant material to be used is to be approximately equivalent in bulk to the bulk of the mineral and is to be applied to the powdered ore in a dry state whereby the buoyant material "is forced into the openings or interstices existing between the atoms constituting the porous, metallic and mineral particles."

The next oil process of ore concentration is that of Robson & Crowder described in U. S. Patent No. 575,669. In this case the powdered ore mixed with twenty-five to thirty-five per cent of water is brought into intimate contact with an oily liquid that is of less specific gravity than water and is capable of taking up the finely divided metallic matter and thus separating it from the substances with which it was previously mixed. The process is the converse of the Haynes and Everson processes. Instead of washing out the gangue from any oily mass with water, Robson and Crowder try to wash out the sulphides from a watery ore paste by the means of a stream of oil. I have tried the process. It is of no use.

It is at this stage that the Elmore bulk-oil flotation processes appear.

In July, 1902, I learned of the Scammel process which was a modification of the Elmore process in which the oil was treated with sulphur chloride. Mr. Scammel was a client of my firm and I patented the process which was taken up by another client
449 of my firm, Mr. Wolf. We introduced Messrs. Scammel and Wolf to Messrs. Sulman and Picard, who made a vigorous attempt to carry the process into effect, but without success.

I have already referred to the Cattermole process which appeared in November, 1902. In July, 1903, Messrs. Sulman (399—322) and Picard invented the process which has been referred to in this case as the "Bubbles" process, and I prepared several different patent specifications on this process and filed these at the British Patent Office, in July, 1903, and in the following months.

The first process to which Messrs. Sulman and Picard directed my attention in this connection was as follows:

An ore pulp was agitated with oil as in the Cattermole process so as to produce not shotty granules, but flocculent masses or "flocks" of oily sulphides. Indeed in the tests which I saw I believe the tailings from the Cattermole process were used because these contained such oily flocks. Some powdered calcite was introduced into this pulp and sulphuric acid was added to the pulp, whereupon

bubbles of carbonic acid gas rose to the surface of the pulp and these bubbles showed a tendency to adhere to the oily flocks of mineral and to buoy them up to the surface. Messrs. Sulman and Picard said that they had here indications of a method of separating oiled sulphides from gangue by the attachment of gaseous bubbles to these oiled sulphides, and this idea was embodied in the
450 provisional specifications to which I have referred. Another test that Messrs. Sulman and Picard showed to me was one in which these Cattermole tailings with oily flocks of mineral in them, were introduced into a glass vessel containing a glass worm with minute perforations in it. This worm was slowly turned round in the vessel and air was blown in through the worm, so that minute bubbles of air rose up through the pulp. Here again there was a distinct tendency for bubbles of air to attach themselves to the flocks and bear them up to the surface. In August, 1903, we came across an abridgment of Froment's British Patent No. 12,778 of 1902, in the "Journal of the Society (400—323) of Chemical Industry," and I advised my clients that Froment had anticipated this idea of floating oily flocks of mineral by bubbles of gas chemically generated in the pulp. Mr. Ballot asked me to open up negotiations for the purchase of Froment's patent rights. I communicated with Mr. Zanardo, our agent in Rome, who was also Mr. Froment's Patent Agent, and obtained an option on Mr. Froment's patent rights. In due course I received a description by Mr. Froment referred to in this case as "Froment's Description," and my firm's translator translated this description into English. I am familiar with the French language. I read the translation and checked it with the original, making one or two alterations, and I now produce this translation.

My client made heroic efforts to get some sort of practical
451 results from the Sulman and Picard Bubbles process, or from the Froment process, but without success. I myself made a number of tests on these processes, and in connection with this suit and various other proceedings during the past five or six years I have frequently tried to work these processes. In a laboratory where one can nurse the small quantities of materials dealt with, it is sometimes possible to get indications of a separation of oily flocks of mineral by the Froment process or by the Sulman and Picard Bubbles process described in the United States Patent No. 793,808, and in 1903, the results were sufficiently promising to justify my clients in applying for patents, but nothing practical could be made of these processes. Even if they had been of any use I can see that they would have been replaced by the agitation froth process, which in every respect is a more practical, economic and efficient process of concentrating ores. In this connection I should also add that on no occasion when these bubbles processes (401—324) were shown to me were the oily flocks recovered in anything that could be described as a froth.

Also, in 1903, Sulman & Picard invented the process of skin flotation of oiled metalliferous minerals. This process was also shown to me as applied to the tailings from the Cattermole process, and the

oily flocks were separated from the gangue by bringing the pulp through air on to the surface of water, whereby some of the oily flocks floated off by the surface tension effect while the gangue sank.

Later on Messrs. Sulman, Picard and Ballot jointly worked
452 out this process to a great extent, and invented the process described in the United States Patent No. 879,985. This invention is dependent on the Skin Flotation of oiled metalliferous matter. The phenomenon is entirely distinct from the phenomenon of the agitation-froth. Separations of oiled metalliferous matter from gangue can be obtained by the process described in United States Patent No. 879,985, but the process does not compare with the agitation froth process in economy or efficiency.

Reference has been made to the "Soap" process of Cattermole, Sulman and Picard, described in United States Patents Nos. 777,274 and 788,247. The origin of these patents is as follows: These gentlemen found that when ordinary oleic soap (sodium oleate) was used instead of oil in the Cattermole process, the sulphuric a d in the pulp decomposed the soap, liberating oleic acid through t the pulp. This proved to be, and is, a convenient way of distributing oleic acid throughout a pulp. The invention was described in the British Patent No. 17,109 of 1903, and when a corresponding application was lodged in the United States, it had to be divided into the two Patent Applications referred to, one of which includes the use of the soap (402—325) reaction in the Cattermole process, and the other of which includes the use of the soap reaction in the Froment process. As a matter of fact, I have never seen the soap reaction used in the Froment process.

The Schwarz process, described in the United States Pat-
453 ents No. 807,501 and 807,503, was brought to me by Mr. Schwarz some little time after the application for the patent in suit. His process closely resembles Haynes' process in that the powdered ore is first mixed with a mixture of oily matter and fatty matter, so as to make a thick, pasty mass, after which an attempt is made to wash the gangue out of the mass with water. I have tried processes of this type many times, and I know they are quite useless.

For the sake of completeness, I may say that I have read the United States Patent Specifications of Kirby, Nos. 809,959, and 838,626, and I have tried to reproduce the processes therein described, but the process is of no use, and, as in the case of the Elmore process, the amount of oil necessary is prohibitive. A number of patents have been taken out for the concentration of graphite ores by the use of oil. Among these are the U. S. Specifications of Glogner, No. 736,381, Good, No. 745,960, and Kendall, No. 771,075. These processes depend upon the same phenomenon as the Elmore process but in so far as graphite is very easily floated by oil, a smaller quantity of oil can be used with graphite than with metallic sulphides. I have seen the agitation-froth process applied to a graphite ore with extraordinary good results, but I have never tried any of these earlier bulk-oil methods on graphite ores. Indeed, the expense of all bulk oil methods would prohibit their use in the treat-

ment of graphite ores, where the margin of profit is, of
454 course, much lower than with valuable (403—326) minerals like zinc, lead and copper.

23 Q. Now, please give consideration to processes of ore concentration in which oil is not employed, such as are described in patents prior to April 12, 1905, and familiar to you.

A. The first process of this type was that described in Bradford's U. S. Patent No. 345,951. In this process powdered ore in water is drained so that the particles are exposed to atmospheric air, after which they are caused to meet the edge or surface of a still body of water, whereupon certain particles float off on the surface of the water, and are thereby separated from other particles which sink in the water. At the end of 1904, and at the beginning of 1905, Messrs. Sulman, Picard and Ballot, without knowing of Bradford's process, worked out a process on the same lines, which is described in British Patent No. 5,260 of 1905, which patent is now abandoned. This process, which was briefly described as skin flotation without oil, was given a very thorough trial in 1905, 1906, and the early part of 1907, because in so far as the process involved the use of no oil or other agents, an economy in this direction might have been effected if the process had been a success. However, it is only very rarely that an ore will give anything like a reasonable separation by such a method. The process is not applicable to slimes, and as the floating particles are in the form of a film, or in patches one particle thick, the area of the separating surface has to be very large,
455 and there is great difficulty in keeping it sufficiently still to allow of any skin flotation. Unfortunately, also, some gangue materials are floated by skin flotation as readily as associated mineral. My clients spent large sums of money in trying to get some useful results (404—327) from this skin flotation process without oil, but without avail. The Bradford patent was brought forward by the United States Patent Office against an application for a patent corresponding to the British Patent No. 5,260 of 1905, and the United States application was therefore abandoned.

The next non-oil flotation process for the concentration of ores is that of Potter described in the United States Patent No. 776,145. In this process an ore, after being powdered or pulverized, is placed in a vat or vessel, and a solution is then added consisting of water with the addition of from one per cent to ten per cent of sulphuric acid, generally two and a half per cent of sulphuric acid. Heat is applied to the vat to bring the temperature of the pulp in practice up to about 85° Centigrade, that is, a little short of boiling point. The effect of the acidulated solution becomes apparent by the bubbling up and gathering on the surface of the fluid of the metallic concentrates in the form of a pasty mass. I have tried this process frequently. It is a process which is only capable of use in a very few instances where it just happens that at this high temperature, carbon dioxide gas is evolved from the ore in such a way as to
456 attach itself to the sulphide particles and bring them up to the surface.

The next process of the same class is that of Delprat described

in the United States Patent- No. 735,071 and No. 768,035. Th process is dependent on the same factors as the Potter process. Th finely ground ore is introduced into a bath or solution either nitric acid or acid sodium sulphate (a saturated solution). I practice the solution was heated to a temperature very little short boiling. Gaseous bubbles are generated chemically from (405—328) the ore, and attaching themselves to the sulphides, carry the to the surface. Here, again, the process is only applicable in certa specific cases.

In both the Potter process and the Delprat process it is importa that the pulp should not be in a state of turbulence and that t powdered ore should not be stirred up into the pulp. The po dered ore immersed in the hot acid solution is gently turned ov so as to allow the particles with adhering gas bubbles to rise to t surface.

24 Q. Please now give brief consideration to the patents to Hoc ley, 466,753; Rouse, 469,599; Stoveken, 729,805; Wagner, 373,11 and Wolf, 787,814; which have been referred to by the defenda and not included in your preceding answers.

A. Hockley's U. S. Patent 466,753 discloses an "ore slimer." Hockley's method is not a process for concentrating ore, but method of saving the lighter suspended matter in slimy water co taining valuable slime particles, such as gold slimes. Th
457 pulp is obviously one from which the bulk of the metalli matter has already been removed. *In* consists of water co taining worthless gangue and valuable slimes. Hockley uses no o or anything of that sort, and does not mechanically agitate the pul Hockley merely bubbles air, water or steam through slime pulp s as to cause an upward current to carry the flour gold upwards an away. The reason for this is that the particles of flour gold are s small that they will not sink in water and are readily carried u wards by an up-current. There is no selective adhesion of gaseo bubbles to mineral particles and there is no froth formation. Indee there is no real flotation in Hockley's method. The flour gold is i suspension in water, and flour gold having a great (406—329) ar in comparison with its weight, is easily carried away in a curren The air, steam or water is only used to create such a current. Th mineral particles are not oil-coated, nor are they attached to a bubbles, nor are they floated to the surface to form a froth. So f as I can see, the specification of Hockley is of no interest in the su ject under consideration.

Rouse, in United States Patent No. 469,599, is not dealing wit ores, and his process is not a process of concentration. Rouse aim at separating slime or fines from the water used in milling ores. I milling an ore, a good deal of slime is formed and it will not sett in water. Before anything can be done with the suspended matte it must be removed from the water, and Rouse's object
458 merely to get the very finely divided solid matter out of t water.

The essence of Rouse's process can be seen from page 1, lines 9 to 96, where it is stated that:

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"The constant upward circulation of air through the slime water tends to elevate all foreign matter to the surface of the water and to create or form a mass of strong foam having a great carrying energy for matter foreign to water."

Stoveken's United States specification 729,805 describes and illustrates an apparatus for use in the cyanide process, and Figures 2 and 3 show the agitation tank. I have personally not seen this specification prior to this suit. I have tried the agitation-froth process many times and I have used various types of apparatus for agitating and aerating the pulp as set forth in the patent in suit. I think that if the Stoveken apparatus could be rotated at a sufficiently high speed it might be used in the agitation stage of the agitation-froth process, but I have never seen a Stoveken apparatus, and I do not know whether it has ever (407—330) been used even in the cyanide process, which is, of course, a process for dissolving gold by chemical action, and not a process for ore concentration.

Wagner's United States Patent No. 373,113 describes a churn. The essential feature of the invention is the use of suspended dashers operated to revolve in reverse directions upon nearly vertical shafts.

The dashers consist of spiral blades intercalating with one
459 another. I have never seen Wagner's specification before today, and have never heard of the Wagner churn being made or used. I take it that it is suggested that a churn of this type could be utilized at the agitation stage of the agitation-froth process, and, provided the apparatus was furnished with suitable inlets and outlets, and provided it could be operated at a speed sufficiently high to bring a microscopic quantity of oil into intimate contact with the metalliferous particles in an ore pulp and to introduce air into the pulp as described in the patent in suit, I have no doubt the apparatus could be used in the agitation stage of the agitation-froth process, but I have not tried it.

Wolf's United States Patent No. 787,814 refers to the use of an agitator lettered B in the drawings. I personally made this drawing, or the sketch from which it was reproduced. The agitator was obtained by Messrs. Sulman & Ficard from Mr. S. H. Johnson of Stratford, London, E. An agitator of this type is capable, when rapidly rotated, of giving the same type of mixing and aeration as the Gabbett or cone mixer. In the Wolf process the object was to agitate a large body of oil with the ore pulp so as to break up the oil into small globules, purposely to produce what we have referred to as "the frog's spawn effect." This mass of oil globules entrapped a large proportion of mineral and (408—331) also a large proportion of gangue and the oil was run off and introduced into vessels containing hot water where the oil globules rose to the surface and it was

intended that the hot water should cause the oil to drop the
460 gangue. The experiments in this direction which I saw were nugatory. Under the conditions of this process no froth was produced, but simply a large body of all oil broken up into small globules and containing a lot of ore.

The Froment drawings were received at my office at the same time

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as the description. The translation referred to by me includes th descriptive matter of these Froment drawings.

The documents heretofore marked for identification "Froment De scription," "Froment Plan" and "Froment Drawing A" are put in evidence, with corresponding titles. The translation produced b the witness is put in evidence as "Complainants' Exhibit Translatio of Froment Description and Descriptive Matter of Froment Draw ings."

In my visits to the works' laboratories of Minerals Separatio during the past years, I have frequently seen what one always see in the agitation froth plant in operation, namely, a thick, coheren and persistent froth floating over the body of liquid in the spit boxes. I recollect that on one occasion, at Charlotte Street, one o the staff picked up an ordinary shovel or spade with a heavy iron blade and put it on the froth, which was not broken, but supported the blade along the surface of the spitz box. This has to be seen to be believed.

27 Q. What in general is the law of Great Britain as to the patenting of inventions so far as relates to the requirement of inventorship in the applicant, and specifically (409—332) what has been
461 your advice to your clients, Minerals Separation, Limited, and predecessors, including Messrs. Sulman, Picard and Ballot as to this point and what has been the practice of these clients in this matter?

A. Any person may make an application for a British patent provided that he is the true and first inventor, or applies jointly with the true and first inventor or inventors, or has received the invention from abroad. Two or more persons may make application for a British Patent, and a patent may be granted to several persons jointly, some or one of whom only are or is the true and first inventors or inventor. The application must be accompanied by a declaration (equivalent in England to an affidavit) stating, in the case of a joint application, which of the applicants are or is the true and first inventors or inventor. In other words, the application may be made by the actual inventor or inventors, together with others but the application form must state which of the applicants made the invention.

With regard to British Patent applications I have advised Messrs. Minerals Separation, Limited, and their predecessors to make applications in the names of the actual inventors or inventor, although in some cases the name of the company has been added according to a common British practice. It is more convenient under the terms of the International Convention to make the application of origin namely, the British application, in the actual inventors' names be cause in certain other countries and colonies it is compulsory
462 that the applications shall be made in the names of the true and first inventors only.

I have been familiar with the American Patent Law since 190 and a large part of the work of my firm involves the procuring of American patents. When I received instructions (410—333)

apply for an American patent I always made it particularly clear that the application must be made by the actual and original inventor or inventors.

I have particularly brought this to the attention of Minerals Separation, Limited, and their predecessors when I have been instructed to make applications for American patents for them. I clearly recollect prior to the application for the patent in suit, taking steps to insure that the application should be in the names of the actual inventors.

An examination at the British Patent Office of the records of the Patent Application in which Minerals Separation, Limited, are interested shows that the applications have been made in the names of the true and first inventors who have declared themselves so to be, and that in a few instances the corporation Minerals Separation, Limited, has been joined as an applicant, and of course specifically excluded from the declaration of inventorship, and that in a few other instances where the true and original inventors were abroad and it was necessary to file the application without delay, the applications have been filed either by the corporation or by some member of my firm as the applicant, naming the true and original
463 inventor or inventors as the communicator or communicators.

28 Q. Have you read the testimony which has been taken in this suit?

A. I have.

29 Q. In your investigations of the literature of metallurgy and of patents relating to metallurgy and your experience in metallurgy have you ever encountered any process of ore concentration prior to the agitation-froth process or referred to in any of the documents in this case, (411—334) other than the agitation-froth process, in which an ore pulp was violently agitated and flowed into a spitz box and in the spitz box a froth floated on the surface of the liquid?

A. No.

30 Q. Referring now to the apparatus which has been described in the evidence in the depositions of Edward H. Nutter, Jesse C. Gibson and James H. Hyde and which has been generally identified as defendant's experimental plant, could this apparatus be used for any of the prior processes or other processes referred to in the last question except the agitation-froth process so as to produce a floating froth in the spitz boxes of the type described by Mr. Nutter in his deposition?

A. No.

31 Q. Assuming that powdered ore, water acidified with sulphuric acid, and oleic acid, are fed into the defendant's apparatus, referred to in the last question, what have you to say as to what would happen?

A. Firstly, if this operation were performed so as to pro-
464 duce a floating froth of concentrates in the spitz boxes, the operation could only be consistent with the use of the agitation-froth process as described in the Patent in Suit. Secondly, if the amount of oleic acid used were too low to produce the agitation-froth, it is obvious that the froth would not be produced. Thirdly,

if the amount of oleic acid were in excess of that necessary to produce the agitation-froth in the most efficient and economical way, part of the sulphide contents of the ore would be agglomerated into little flocks which would sink in the spitz box and the froth would no longer be a good and efficient froth. (412—335)

32 Q. Now, referring to defendant's second plant as described in the deposition of Eugene A. Byrnes, would you in any way modify your answers to 30 and 31 Q. in relation to this apparatus?

A. No.

33 Q. What have you to say as to the suggestion that the retreatment of concentrates and of the residues obtained from the retreatment of concentrates, constitute either separately or collectively, a departure from or an improvement on the agitation-froth process as set forth in the Patent in Suit?

A. The concentration of an ore or like product is an operation involving the treatment of the ore with the object of increasing the proportion of the valuable constituents in relation to the worthless constituents or gangue, and is carried out either by removing from the ore a portion which consists mainly of gangue, in which
465 case the remaining ore is enriched, or by removing from the ore a part in which the proportion of valuable constituents is higher than in the original ore. It is an axiom in ore dressing that so long as it pays to enrich a product by concentration, the treatments above referred to should be continued or repeated and it is thus everyday practice to retreat tailings or middlings containing values, for the extraction of the values therefrom, or to retreat concentrates to improve the grade thereof, and this axiom applied to concentrates, middlings and tailings at any stage in ore-dressing operations.

I say that in the agitation-froth process the retreatment of the tailings or of the concentrates or of the tailings from retreatment of the concentrates, either separately or collectively, does not constitute a departure from or an (413—336) improvement on the agitation-froth process as set forth in the Patent in Suit, and such operations of retreatment would not in any case be of an inventive character.

As a matter of fact in the tests carried out in the Minerals Separation Works and Laboratories, it has been common practice for years back to retreat either tailings or concentrates, and indeed in the Patent in Suit the further treatment of the tailings is referred to.

In the year 1910 and in the early part of 1911, Minerals Separation had plants erected specially for the purpose of producing a dirty concentrate by the agitation-froth process and of retreating this concentrate again by the agitation-froth process. The plant and one of the processes carried out in it had novel features which
466 formed the subject of patents in 1910, but although retreatment was used I inserted in the patent applications no claims thereto because I knew that these retreatments were matters of daily practice and common knowledge among those accustomed to the use of the agitation-froth process.

The numbers of these patents are Nos. 23870/1910 and

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23949/1910, both British Patents. The first patent No. 23870/1910 covering a process of differential flotation, and the second patent No. 23949/1910 covering an apparatus known as the "Froth Trap" Apparatus, and the process carried out in each case is the agitation-froth process.

Cross-examination:

39 X Q. As the Cattermole process for causing granulation and precipitation of the valuable parts of an ore has been described there are two stages of agitation, one carried out in a cone mixer having baffles and the other carried out in a cone mixer, cylindrical in form, and having no (414—337) baffles. I presume there is quite a marked difference between the effect caused by the use of the cone mixer with baffles as distinguished from its use without baffles. Is that correct?

A. I think the agitation in a cone mixer from which the usual baffles have been removed is much less violent than in an ordinary cone mixer.

40 X Q. And this less less violent agitation which takes place without the baffles is an important feature of the Cattermole process, is it not?

467 A. I should not like to say anything about its relative importance. The granulation phenomenon is chiefly a function of the proportion of oil added to the ore pulp. In the first investigation of the Cattermole process, that is in Mr. Cattermole's own tests, the experiments were done in bottles. It was Sulman, Pickard and Ballot who introduced the cone mixer and one or other of these gentlemen tried to make the Cattermole granules more shotty by gentle rolling agitation, and one of the ways in which they did this was to use an ordinary cone mixer from which the baffles had been removed and in which the cone was rotated at a very much lower speed than was necessary for bringing the oil into efficient contact with all the mineral particles in the pulp, as in the actual cone mixer used at the commencement of the Cattermole process.

42 X Q. Do you find this two stage agitation in any way referred to in Cattermole United States Patent 777,273?

A. Yes. The agitation described with reference to the drawings was carried out in ordinary Gabbetts, but it is stated on page 3, lines 46—50, that "with certain ores it may be preferable to use in some stages of the process a rolling form of agitation, as in cylinders or barrels, to (415—338) obtain good granulation of the mineral."

43 X Q. Do you find anything in the drawing of Cattermole United States Patent 777,273 and the description thereof stating or implying that the agitation is to be of two kinds, one in the
468 cone mixer with baffles and one in the cone mixer without baffles?

A. No, and I think that at the time when I prepared this specification a cylinder was being used or experimented with for the purpose of producing more shotty granules when this was necessary.

Referring to Figure 1 of the drawings of the patent in suit, the

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illustration of the cone mixer is conventional for two reasons, first, because the cone mixer was a well-known device, and secondly, because the patent is for a process, in which it is clearly stated that the ore pulp and a minute quantity of oil is to be vigorously agitated until the oil has been brought into efficient contact with all the mineral particles in the pulp, and it is pointed out that air bubbles are to be introduced into the mass by agitation in such a way as to form a froth. It was obviously therefore proper to use merely a diagrammatic sketch in indicating one form of apparatus suitable for carrying the process into effect, because the directions given in the body of the specification were fully sufficient to enable any intelligent reader to understand what the mixing device was to do.

In a patent specification relating to a metallurgical process, my view is that the body of the specification should inform the operator as to what he is to do to carry the process into effect, and a diagram is sometimes of assistance in showing the sequence of operations of the different elements in the process. I indicated a cone mixer (416—339) in the drawing merely to make the diagram more complete, although so far as I can see the diagram might as
469 well have contained merely a square or a circle bearing the legend "cone mixer" or "Gabbett mixer." In reply to the latter part of your question an operator does not require to "supply" baffles when using a cone mixer. If the cone mixer he buys is square, as they most frequently are, no baffles are required, and if he buys a cone mixer which is cylindrical it will have baffles in it. If the operator made a cone mixer without baffles and found that the agitation was not sufficient to bring about to the greatest possible extent the object desired, I think that the dictates of his intelligence would lead him to increase the turbulence by the use of the ordinary baffles. So far as the patent in suit is concerned I think it is made clear that any number of cone mixers may be used in series and it is certainly made abundantly clear what the nature and result of the agitation is to be.

I remember in the early part of February, 1905, having a conference with Messrs. Sulman, Pickard and Ballot, at which they spoke of the investigations which they were about to make, and we discussed the method in which the results were to be indicated; and I particularly remember these gentlemen stating to me that in their investigations they were going to reduce the proportion of oil used in the Cattermole concentration process to a vanishing point, making the reduction step by step, and noting the results.

52 X Q. What was the purpose of these gentlemen in conferring with you upon this matter?

A. I cannot testify as to the purpose Messrs. Sulman,
470 Pickard and Ballot had in view in keeping me at all times fully informed as to the objects, progress and result of
(417—340) their investigations, but on my behalf I can say that it has always been of the greatest possible assistance to me to be kept so fully informed, and I think my advice on patent matters has been of greater value to my clients than if they had only

brought to my notice completed inventions, or specific questions for legal opinions.

Prior to April, 1905, I do not recollect ever having seen any mineral-carrying froth at all and certainly I had not seen a mineral-carrying froth which was thick, coherent and persistent. I recollect in some Froment tests seeing a froth of bubbles by which oily flocks of mineral were projected upwards or borne upward, but I had never seen a mineral-bearing froth before April, 1905, having any resemblance to the thick, coherent and persistent froth produced by the agitation froth process.

The process which I call the agitation-froth process is the process set forth in the Patent in Suit, and when that process is normally operated to its proper purpose and effect it results in this very characteristic phenomenon which I term a thick, coherent and persistent froth. The process as a whole is entirely distinct from the Froment procedure and the froth produced by the process of the Patent in Suit is quite distinct from anything which I had seen produced by the Froment process. The froth of bubbles which I had seen produced by the Froment procedure was produced in a test tube.

471 British patent No. 7803 of 1905 corresponds with United States patent No. 835,120 in suit.

When I prepared the application for United States patent No. 835,120 in suit and the application for patents in other countries upon the same subject matter, I did not (418—341) have before me and was not conversant with the document which has been introduced in evidence as "Froment Description" and the Drawings in evidence as "Froment Plan" and "Froment Drawing A," but I had known the Froment patent specification No. 12,778 of 1902 since August, 1903, and I was conversant with the Froment process.

The Froment British Patent No. 12,778 of 1902, is vague and ambiguous and in several respects does not give a sufficient disclosure to enable a metallurgist to carry out a process for the concentration of ores in a satisfactory manner. The Froment description and drawings help to elucidate the specification and the essential features of the Froment process can be defined as follows: The process starts with an ore pulp consisting of powdered ore in water. The first step in the process is to add a suitable oil so as to unite the sulphide particles into what Froment calls "spherules" or what Sulman & Pickard call "flocks." These are little masses of metallic sulphides moistened by oil and as stated by Froment they are at the first stage of the process imprisoned in the gangue. The next stage of the Froment process consists in liberating a gas in this mass, and Froment proposes to do this by the action of
472 sulphuric acid or calcite or the like. The object of this second step is that the bubbles of carbonic acid shall attach themselves to the oily flocks of mineral and buoy them up to the surface. The third step in the Froment process consists in the separation of the concentrates from the oil in a hydraulic press or filter press whereby Froment states that a very large proportion of the oil

used can be recovered. The fourth step in the process is the re-admission of the recovered oil into the cycle of (419—342) operations. Froment's concentrates according to his process was to be removed from the filter press in the form of cakes.

In the light of the Froment British Patent No. 12,778, of 1902, and the Froment drawings and instructions which have been introduced in evidence in this case, I should proceed to apply the Froment process to a sulphide ore containing five per cent calcite in the following manner, but I do not know that I should achieve any measure of success.

I should crush the ore to 120 mesh, and remove the slimes therefrom by a de-sliming process. The powdered ore and water, in the proportion of 2½ kilogrammes of ore to 6 litres of water, would then be introduced into a mixing device. Assuming that the ore contained 30% of metalliferous matter, I should add engine oil to the extent of 56 lbs. per ton of ore. The mixing device would then be put in operation until the sulphide particles had formed the required flocks with the oil. Froment, in his drawings and instructions, stated that the mass at this stage should be run into
473 special vessels for holding the oiled ore. In any case the oiled pulp would be introduced into a second vessel in which the oiled ore would lie at the bottom, and this vessel would be filled with water. Means would be provided in this second vessel for introducing sulphuric acid, and means would also be provided for turning over the oiled ore at the bottom of the vessel, to allow the sulphuric acid to get access to the ore. It is in this vessel that the most important step in the Froment process is intended to take place. The intention is that the sulphuric acid acting on the calcite shall evolve bubbles of carbonic acid, which will attach themselves to the oily flocks of mineral and buoy them to the surface, and from my experience I should expect that some of the flocks would, in fact, be raised in this way. To carry out Mr. Froment's instructions, the (420—343) floating materials should be removed and introduced into a filter press, to squeeze out the bulk of the oil, leaving the product of concentration in the form of cakes. I have never carried out such an operation as I have described, although I have tried the Froment process on a small experimental scale in the laboratory. The process is a very difficult one, and at various stages it requires great care. In the first place, the formation of the oily flocks or spherules of mineral and oil requires a good deal of adjustment, although my own experience has been that with ores containing 30%, 40% or 50% of mineral contents, the proportions of oil specified by Froment in the description put in evidence are such as to produce these oily flocks. As
474 pointed out in Froment's specifications, there is also a proportion to be sought for a given ore and limestone, because in the Froment process it is important that the carbon dioxide shall be evolved from the sunken mass of ore in just such a way as will enable the gaseous bubbles to attach themselves to the oily flocks and bring them to the surface. Again, when the oily flocks come to the surface, there is in practice a good deal of difficulty, because

the bubbles of carbon dioxide frequently burst, and let the flocks of mineral sink again. The process is one which, in my opinion, could not efficiently be carried into practice. It requires too many fine adjustments; the quantity of oil necessary is prohibitive; the quantity of acid necessary would be a very serious item on the large scale if the margin of profit were comparatively low; the filter press operation, in my opinion, would not be effective, and the adjustment of the amount of calcite and of its decomposition is also, in my opinion, too difficult for practical operation. (421—344)

77 X Q. The froth produced in the operation of the so-called agitation-froth process is composed, is it not, of a large number of bubbles, more or less covered with the metallic sulphide particles of the ore?

A. In answering this question I shall have to make statements bordering on theory, and I am, therefore, expressing only my opinion. It is known to students of molecular physics that a persistent froth of air and water cannot be produced unless the water films are contaminated. In my opinion the froth produced
475 in the operation of the agitation-froth process set forth in the patent in suit is composed of bubbles of air, the walls of which consist of water contaminated with myriads of particles of very finely divided sulphides, and the surface tension relationship between the sulphide particles on the one hand, and the water and air on the other hand, has been altered by the minute trace of oleic acid or other oil. An inspection of the agitation-froth shows that the walls of the bubbles are contaminated by these sulphide particles; and it is a fact that the agitation-froth process operates most effectively when a large proportion of the sulphides is in the form of slimes; that is to say, when a large proportion of the sulphides will pass through a screen of 150 or 200 meshes to the linear inch. It is noticeable in the agitation-froth process that the sulphide particles still retain their natural appearance, and they are not in the form of flocks.

78 X Q. In any event, the froth formed as a result of the operation of the so-called agitation-froth process consists of bubbles, the walls of these bubbles being formed of water contaminated by or containing metal sulphide particles, the formation of such sulphide-bearing bubbles being promoted by the oil present. Is this not correct, disregarding (422—345) for the moment any scientific discussion of the minutiæ of the matter?

A. This is correct, and it is a remarkable fact that this characteristic agitation-froth can only be produced by the process described in the patent in suit, so far as I am aware.

476 79 X Q. Froment in his British patent stated that the bubbles of the gas become covered with an envelope of sulphides. Isn't this expression a pretty fair description of the so-called agitation-froth which is formed of bubbles, the walls of which are composed of water containing metal sulphide particles?

A. No. In the first place in the passage referred to, it is the bubbles of the liberated gas, namely the carbonic acid gas, to which Froment refers. In the second place it is not suggested in the passage

from Froment's specification that the bubbles have walls consisting of water-films, and there is certainly nothing in Froment's specification suggesting a froth in any way resembling the agitation-froth produced by the process of the patent in suit. In my opinion a confusion has arisen in the specification of Froment. When the Froment process is tried with a test tube, the carbonic acid gas is confined within a narrow space. Such flocks as are floated are caught on the top of the rising body of gas and so one frequently finds a layer of carbonic acid gas bubbles which are clean and which have of course water walls, and above that an envelope of the sulphides which are in the form of oily flocks. The bubbles of carbon dioxide actually in contact with the oily flocks have in my opinion walls of oil. When the Froment process is carried out on a larger scale as in the experiment described in the testimony of Mr. George A. Chapman the oily flocks rise away from the ore individually (423—346) with bubbles of carbon dioxide gas attached to them
477 and in such cases also, in my opinion, the walls of the bubbles of carbon dioxide are oil. It goes without saying that in no case in the Froment process is a froth produced consisting of bubbles of air, the walls of which are water films contaminated by myriads of individual sulphide particles which are not "moistened" with oil, as is the case in the agitation-froth. I am also of opinion that in the case of a document like Froment's British Patent specification No. 12,778 of 1902, one cannot obtain a proper idea of the process which the patentee intends to disclose by selecting out and reading a short passage divorced from its context, but that to appreciate the process one must see what the whole intention of the patentee is and, if possible, what he actually does when the process is reduced to practice.

In 1902, the "oil process of ore concentration" referred to by Froment was the Elmore bulk-oil process which was the only one publicly known or tried on the commercial scale, and in that process the layer of oil added was very thick and amounted to from 100 to 300 per cent on the ore. The Elmore bulk oil process was tried at the Traversella Mine in Italy where Mr. Froment was the engineer, and it is clear to me that Froment wished to use a smaller quantity of oil then Elmore did.

With regard to the direction in Froment's specification to use a thin layer of ordinary oil, this direction refers to an experiment in a test tube. I notice that Froment suggests the use of a few drops of sulphuric acid but does not suggest the use of merely a few
478 drops of ordinary oil, but "a thin layer" of ordinary oil. I have frequently tried the Froment process in a test tube and I find that the thin layer of oil amounts to not less than about 5 per (424—347) cent on the weight of ore (that is 112 lbs. of oil per ton of ore).

I have also found that in a test tube experiment such an amount of oil is in fact necessary to cause the sulphides to be moistened by the oil and to unite into the flocks or spherules required in the Froment process. Turning for a moment to the agitation-froth process I point out that no metallurgist would ever think of adding a thin

layer of ordinary oil to the pulp in that process. It would be ridiculous to attempt to carry out the agitation-froth process in a test tube by additions of the type suggested in the Froment test. Assuming that the test tube contained 10 grammes of sulphide ore, the amount of oil necessary to give the proportions required for the agitation-froth process would be one-fifth of a drop or less, an addition which of course is out of the question.

It must be borne in mind that the production of oil used in the Froment process must be such as to produce the spherules or flocks of sulphides moistened with oil and in my experience, with the ores I have tried, the amount of oil necessary for the Froment process varies from about 25 times to about 40 times the amount of oil necessary in the agitation-froth process, and in any case the quantity of oil necessary for the Froment process is always many times
479 the quantity required for the production of an agitation-froth. Turning to the Froment instructions of record, it is clear that Froment recommends that the quantity of oil should be to some extent varied in proportion to the metalliferous contents. I have not tried the Froment process on ores containing less than 10% mineralization and as far as I am aware the process has not been tried with such ores, but taking ordinary ores with a (425—348) mineralization of from 10% up to 50%, the proportion of oil recommended by Froment in his instructions varies from 44.8 lbs. of oil per ton of ore containing from 10 to 15 per cent mineralization, up to 78.4 lbs. of oil per ton of ore containing 40 to 50 per cent mineralization. I am strongly of opinion that these proportions could not be reduced within the limits of the Froment process. In view of these statements appearing in Froment's patent and instructions, I am satisfied that a metallurgist would in the exercise of ordinary common sense use the quantities of oil necessary for the formation of the flocks or spherules which are in my opinion the quantities recommended by Froment.

Turning to the agitation-froth process described in the Patent in Suit, it is clearly stated on page 1, line 96, "the minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of a froth may be under 0.1 per cent of the ore; but this proportion has been found suitable and economical." This statement clearly directs the metallurgist to use 2.24 pounds of
480 oil per ton of ore or less, and my experience is that 2 pounds of one and a half pounds of oil per ton of ore is an ideal standard for the agitation-froth process. In the agitation-froth process the minute trace of oil added is not proportioned to the metalliferous constituents of the ore. In my opinion a metallurgist in putting into operation the agitation-froth process would start with 0.1 per cent of oleic acid on the ore, and this would probably give him a good result. If he found that there was a tendency for some of the metalliferous particles to agglomerate together and sink, he would reduce the quantity of oil from say 2 pounds of oil per ton of ore down to say 1½ pounds of oil per ton of ore. (426—349)

Apart from these considerations as to the proportion of oil used which bring out fundamental distinctions between the Froment pro-

cess and the agitation-froth process, I wish to say that no fanciful or imagined variations in the quantity of oil necessary in the Froment process could possibly convert the Froment process (which depends upon certain phenomena) into the agitation-froth process, which depends on a very unique, characteristic and entirely distinct phenomenon.

87 X Q. You have frequently used the expression or an expression equivalent to the following: Agitated so as to introduce air. Is there any kind of agitation that would cause efficient contact of oil in quantities as low as one per cent of the ore with the metalliferous mineral particles of the ore, that would not cause air to be entrained in the liquid?

481 A. Except by using extraordinary expedients such as an agitation vessel in vacuo, or an agitation vessel completely closed and completely filled with pulp, I cannot at the moment suggest any kind of agitation for the purpose referred to, that would not cause air to be entrained in the liquid, but I have not tried any experiments for the purpose of oiling an ore in a pulp without entraining any air into the pulp.

As the meaning of the word "entrained" is not very definite, I may say that I have used the word as meaning that air would be drawn into the liquid; of course, normally the air would come out again and the question whether any air would remain in an agitated liquid depends on other considerations. In my opinion, in the first agitator of the Froment apparatus air would pass into the pulp and out again. (427—350)

When the cone mixer is used in the conditions set forth in the patent in suit, air is drawn in and then forced or permitted to flow out again in enormous quantities.

As an example of numerous tests which are conclusive on this point, I have put the cone mixer into operation for one or two seconds, using vigorous agitation when the cone mixer has contained plain water and other liquids or pulps, and I have seen the air bubbles scouring through in the water even in this short time.

96 X Q. Do you find the word "flocks" anywhere in the

482 Froment specification or in the Froment description?

A. No. It would have been more correct in my answers to have adhered throughout to the expression "spherules" employed by Froment. The essential first step in the Froment process is to form little masses of sulphides moistened by oil and throughout my evidence I have used the word "flocks" in the sense of these little oily masses only.

97 X Q. Did you use the word "flocks" in the sense in which it has been applied to the particles formed at one stage of the Cattermole process?

A. I did, but the little oiled masses of mineral in the Froment process contained more oil than the flocks in the Cattermole process. I know this because it is impossible to squeeze any oil out of the Cattermole agglomerations of flocks, whereas the little oily masses in the Froment processes were, according to his directions, to be collected together and squeezed to remove oil for re-use.

In my opinion, the operation of the agitation-froth process is defined in the clearest possible terms in the (428—351) patent in suit, and this remark applies particularly to the quantity of oil to be used. It is a fact that 0.1 per cent of oil on the weight of ore is a suitable and economical quantity to use for the production of the agitation-froth, in the instance given in the patent and in those instances where I have seen the process in use. Less oil than this may also in some instances be effectively used as stated in the patent in suit.

483 It is further made clear in the patent in suit that the quantity of oil used must not be such as to cause agglomeration as in the Cattermole process. If a metallurgist used a quantity of oil sufficient to cause the sulphide particles to agglomerate and sink, he would be using too much oil for the process of the patent in suit; and further, if a metallurgist was minded to carry out the agitation-froth process as defined in the patent in suit, and if he used more oil than is necessary to produce the agitation-froth, he would be doing something wasteful, and in ore concentration economy is of first-rate importance. The fact is that Sulman, Pickard and Ballot found that when the proportion of oily substance was considerably reduced from the Cattermole quantities, and after vigorous agitation of the pulp, the tendency of the froth to form began; and when the proportion of oil was reduced to 0.1 per cent they found that an efficient agitation-froth was produced. I have never seen the agitation-froth process successfully carried out by the use of an amount of oil equal to practically one per cent by weight on the ore, and in my opinion 0.9999 per cent of oil would not be a proper quantity (that is to say, it would not be a suitable and economical quantity) as contemplated by the patent and would not therefore be a suitable fraction of one per cent as contemplated by the patent. (429—352)

In the agitation-froth process the time element or the contact period is of great importance. The pulp in the agitation-froth process contains a large proportion of very finely divided mineral

484 particles. It is fundamental that the minute bubbles or films of air shall collect all these minute sulphide particles. The time of agitation necessary for this collection is the time element or contact period to which I have referred, and froth cannot properly be obtained or separated on the spitzkasten until this time of agitation has been completed. During this time there is beaten into and out of the pulp a quantity of air many thousand times that which is included ultimately in the froth, and during that time I am satisfied that the carbonic acid gas would almost completely escape. Sulphuric acid and calcite cannot exist together under the circumstances described; they are bound immediately to react until one or other is completely destroyed, so that the carbon dioxide formed disappears during the time interval I have referred to, and I am satisfied that if the process were carried out so as to form a froth, there would be substantially no calcite or no sulphuric acid in the pulp when it reached the spitz box.

104 X Q. I presume it is your opinion that a competent metal-

lurgist reading the Froment patent would understand that suitable apparatus was to be used in carrying out the process which Froment described.

A. A competent metallurgist reading the Froment patent would see that it does not adequately disclose any process of ore concentration, and certainly he would require to find out how the process in fact was to be carried out, and what apparatus was to be used. When I negotiated for the purchase of Froment's pat-
485 ent, on behalf of Mr. Ballot and (430—353) his associates, I made it clear, or it was made clear, that Mr. Froment would have to give particulars as to how his process was to be carried into effect, and what apparatus was to be used, and the particulars supplied have been put in evidence.

105 X Q. When did you first see these particulars, by which I understand you refer to the Froment plan and Froment Description?

A. I actually saw them only quite recently, within the last month, but in the latter part of 1903, in the early part of 1904, and at various times since then, I have discussed the Froment process with my clients, and I have seen attempts made to carry it into effect, although not in the apparatus supplied by Mr. Froment.

106 X Q. From the testimony which has been given in this case, and with which I understand you are familiar, I take it that the parties interested in Minerals Separation, Limited, completed the purchase of the Froment British patent prior to receiving Mr. Froment's description, plan and apparatus?

A. Yes.

(The witness produces and identifies drawings of the plant heretofore referred to as the Australian Model Plant.)

The drawing referred to is put in evidence as "Complainants' Exhibit Drawing Australian Model Plant."

(The attention of the witness is called to an article in "The Daily Herald Democrat," of Leadville, Colorado, dated October,
486 1889, and to an article in the "Enginering & Mining Journal," dated November 15, 1890, and he admits that these are publications known to him.) (431—354)

The publications referred to are put in evidence as "Complainants' Exhibit Fryer Hill Publication" and "Complainants' Exhibit Criley & Everson Publication," in the order above named.

The apparatus shown in the "Froment Plan" is intended to be used in the manner described in the "Froment Description." The operations set forth in the Froment description constitute the method and the only method known to me in which Mr. Froment intended that his process should be reduced to practice. The Froment apparatus comprises several parts, two of which are the most important, namely, the centrifugal mixing device and the vat with coil. The only method of using the centrifugal mixing device on the one hand, or the vat with coil on the other hand, consistent with Froment's process, is the method set forth in the "Froment's Description." The method of using the vat with coil is fundamental to the Froment process. The vat with coil is filled with

water, at the bottom of which is a mass of ore in which the little oily masses containing the sulphides are imprisoned. At this stage carbon dioxide gas is generated in a nascent state in this mass at the bottom of the vat, the intention being that the bubbles of carbon dioxide, as they are generated, shall attach themselves to the little oily masses and buoy them to the surface. This generation of carbon dioxide gas takes place im-
487 diately the sulphuric acid comes in contact with the calcite.

If a Gabbett mixer were to be used at this stage of the Froment process so as to beat in air, say for two and a half minutes, this would be utterly inconsistent with the Froment process and would be entirely destructive of the Froment phenomenon. Froment having given clear instructions that the mass of ore containing little masses of oil and sulphides (432—355) to be introduced into a vat which is filled with water, and that carbon dioxide gas is to be generated, that is to say, produced in a nascent state in that sunken mass so as to allow the nascent bubbles of carbon dioxide to attach themselves to these oily masses, and Froment having made it clear that this sunken mass is to be slowly turned over at the bottom of the vat to allow the oily masses and attached bubbles of carbon dioxide to escape and come to the surface, a metallurgist who would replace this operation by a violent agitation such as is employed in the agitators of the agitation-froth process would be deliberately departing from Froment's instructions, be deliberately destroying the essential part of the Froment process, and would, in my opinion, be doing something deliberately misleading and unfair.

On the other hand, if in the Froment process as described in the "Froment Description" a metallurgist were to replace Froment's centrifugal mixing device by a Gabbett mixer which introduced air in large quantities, he would not, in my opinion, be doing any-
488 thing inconsistent with the Froment process, and this is what my clients did, with the full knowledge of what the Froment process was. Or, if Froment's centrifugal mixing device was used as described in the "Froment Description" and if air were beaten into the centrifugal mixing device, as in my opinion it would be, this would not be inconsistent with Froment's process, but would and does constitute the first step of the Froment process.

The process set forth in the Froment British Patent No. 12,778 of 1902 was protected by Letters Patent only in England and Italy. I made a search to see whether other patents had been issued and also heard from Mr. Froment (433—356) that he had made no patent applications in any other countries. Mr. Froment is dead.

127 X Q. Were you present when certain demonstrations of a flotation process were made on behalf of Minerals Separation Limited before the officials of the German Patent Office?

A. I was.

128 X Q. Tests were made at that time, were they not, using different quantities of oil?

A. Yes. The agitation-froth process and the Cattermole process were both demonstrated.

129 X Q. What quantities of oil were used in these tests of the two processes?

A. The quantities respectively recommended in the Cattermol Patent and in the patent in suit.

130 X Q. I presume that these demonstrations with differen quantities of oil were made for the purpose of illustrating th
489 difference between the Cattermole process and the flotatio effect.

A. Yes, to show the difference between the Cattermole process an the agitation-froth process.

131 X Q. Was the result of these demonstrations such as to induc the officials of the German Patent Office to grant a patent on wha you term the Agitation Froth Process?

A. The patent application had already been allowed, after th process had been thoroughly explained and I think demonstrate to the Patent Office Examiners. The demonstrations at which was present were made in connection with an opposition made b Elmore to the grant of the patent. In the opposition before th Application Department the whole question whether the patent ap plication on the agitation-froth (434—357) process should be al lowed in the light of the earlier German patent of Elmore was gon into and discussed in the minutest detail in arguments lasting severa months, and the Application Department decided that the agitation froth process was entirely distinct from the Elmore process, and a this stage the opposition failed. On appeal there was a hearing a which I was present, lasting for an hour or two, before a tribunal o five gentlemen, who, in my opinion, had not the remotest idea o what we were talking about. Evidence was actually given to th tribunal by the opponents during the argument, without even a offer to the applicants of leave to deal with that evidence
490 and the Appeal Department reversed the decision of th Application Department. I need hardly say that this pro cedure did not incline me to the view that the agitation-froth pro cess has the slightest resemblance to the Elmore process. The fina result of these proceedings therefore was that a German patent wa not granted on the agitation-froth process.

135 X Q. Frequent mention has been made during the progres of the testimony in this suit by the witnesses, including yourself, t Mr. Theodore J. Hoover, formerly General Manager of Mineral Separation Limited. Have you interviewed Mr. Hoover with a view to ascertaining whether his testimony could be secured to illumi nate matters in connection with which his name has been mentioned?

A. No.

136 X Q. Have you interviewed him for any purpose since the taking of evidence in this suit commenced?

A. Yes.

137 X Q. Did you express to him any desire that he should o should not testify in this suit?

A. I informed Mr. Theodore J. Hoover that one of (435—358 the objects of the present Commission was stated to be that he, Mr Theodore J. Hoover, should be called as a witness on behalf of th

defendant, whereupon Mr. Hoover expressed the greatest astonishment, and volunteered the statement that he could not and would not testify on behalf of the defendant in this suit.

I expressed to Mr. Hoover my agreement with him in his attitude, but beyond that I expressed no desire.

491 Redirect examination:

138 R. D. Q. Was the interview with Mr. Theodore J. Hoover of which you have testified at your solicitation?

A. Certainly not.

139 R. D. Q. You have said that Mr. Hoover said that he could not testify on behalf of the defendant in this suit. Can you shed any light on the exact meaning of that expression, as a consequence of your talk with him?

A. Yes. Mr. T. J. Hoover stated that one reason why he could not testify against the Minerals Separation, Limited, was that he had been their manager and at all times an enthusiastic believer in the agitation-froth process. He also stated that he now wished to take no personal part in patent litigation, and he also expressed himself to me as very indignant at much of the evidence given on behalf of the defendant in this suit.

To the best of my recollection, I first saw the Slide Machine at Sulman and Picard's Laboratory at the end of 1909; at any rate, I was familiar with it at the beginning of 1910. Messrs. Sulman & Picard used to call it "The Shear Gabbett" or "Shear Mixer." On the 2d of March, 1910, Messrs. Minerals Separation, Limited, rang up my firm and (436—359) stated that they wished to have some of these Shear Gabbetts made by a regular maker of apparatus of this type. My partner, Mr. Tennant, to my knowledge, recommended that our own model maker, Mr. W. H. Dearden,
492 should make them, and Minerals Separation, Ltd., accepted my partner's suggestion. (437—360)

Testimony for Complainants of George Lockwood Morris.

LONDON, ENGLAND, August 31, 1912.

Direct examination:

I am fifty-three years of age, a resident of London, by occupation office manager of the Anglo-American Import and Export Company. During the latter part of 1909 and the early part of 1910 I was Central Manager of the Emu Smelting Works near Swansea in Wales. While so employed a concentration plant was installed which, so far as I can see, was identical with that illustrated in "Complainants' Exhibit Drawing of 1909 and 1910 Agitation Froth Plants." Ore of the San Francisco del Oro Mine, Mexico, was concentrated in that apparatus. This concentration plant was used for producing concentrates for zinc smelting purposes. The concentrates appeared in the spitz-boxes to be all of a froth and were delivered to me as a wet powder. The total amount of concentrates delivered to me for smelt-

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ing purposes by this concentration plant was about 120 tons. The
were satisfactory concentrates for this smelting operation. Th
smelting operation was the Picard Briquetting process.

Cross-examination:

I frequently saw the operation of the flotation plant at Em
probably almost every day, if not every day. I had no tin
493 to take much interest in it. I made no point of looking
the contents of the spitz-boxes with any particular frequen
or regularity. To the best of my recollection upon every occasio
when I observed the contents of the spitz-boxes and when the pla
was in operation, the liquid in the spitz-boxes was completely cover
with froth.

I remember Mr. Hyde's visit to Emu, but I cannot now (438–
361) remember whether the liquid in the spitz-boxes was or was no
covered with a froth as distinguished from a mere thin film upon th
occasion of Mr. Hyde's visit.

This flotation plant is not now in existence. It has been destroyed

Redirect examination:

The products of the smelting furnace were sold. (439—362)

Testimony for Complainants of Percy Lot Young.

LONDON, ENGLAND, September 3, 1912.

Direct examination:

I am forty-one years of age, a mechanical engineer, and manage
of the mechanical department of H. Young & Company, Ltd., Lon
don, England. I reside in London. I have been connected with H
Young & Company since 1887. Young & Company have manufac
tured a mixing device since 1890 under British patent 840 of 189
to Gabbett and others, and we are still manufacturing it. I produc
an advertisement of Young & Company (introduced in evidence a
"Complainants' Exhibit Young First Circular"), and anothe
494 advertisement from the Journal of the Society of Chemica
Industry, which has a wide international circulation, date
November 30, 1897 (introduced in evidence as "Complainants' Ex
hibit Young Advertisement A"). The circular first referred to wa
issued in 1890, but Young & Company found at The Brewers' Ex
hibition that they were giving away too much information, and
also that people misunderstood the effect of the cone in looking a
the other details. They therefore changed the illustration by leaving
out the baffles from the illustration. We no longer give a section o
the cone, but an outside view, as shown in "Complainants' Exhibi
Young Advertisement A." I also identify an advertisement o
Young & Company (introduced in evidence as "Complainants' Ex
hibit Young Advertisement B"), the same having appeared in "En
gineering" in the issue dated January 3, 1902.

The mixer made by Young & Company was known as "The Rapid Mixer," and it was also known as a "cone mixer." It was advertised to a considerable extent. I can instance (440—363) "The Brewers' Journal," "The Engineer," "Engineering" and "The Journal of the Society of Chemical Industry." In those instances when we supplied the containing vessel of the apparatus and the vessel was of round or cylindrical form, we provided the vessel with baffles, but many clients bought the cone and adapted their own vessels to our instructions, which were the insertion of baffles.

No cross-examination. (441—364)

195 *Testimony for Complainants of Robert M. Kindersley.*

LONDON, ENGLAND, September 4, 1912.

Direct examination:

I am forty years of age, a resident of Langley House, Abbotts Langley, Hertfordshire, a banker, and a partner in the firm of Lazard Brothers & Company. Lazard Brothers & Company entered into an agreement with Minerals Separation, Ltd., to find capital to erect a plant for dealing with tailings at Broken Hill, Australia, and to find capital for purchasing such tailings. The total profit realized from the agreement and the operations thereunder was £181,687-5-9. It was my understanding that the process used was the agitation-froth process. I produce two tables showing profits, the material treated and the results obtained in the operations referred to (introduced in evidence as "Complainants' Exhibit Table of Material and Results of Lazard Ventures").

Cross-examination:

4 X Q. Do you know whether Minerals Separation, Limited, has ever paid a dividend to its shareholders, and if you do what is the fact of the matter?

A. I believe, to my knowledge, not. Their profits have always been used in furthering the ends of the company. (442—365)

196 *Testimony for Complainants of Francis A. Keating.*

LONDON, ENGLAND, September 4, 1912.

Direct examination:

I am upward of twenty-one years of age, a resident of London, a merchant by occupation, and a director of the Sulphide Corporation, a licensee of Minerals Separation, Limited, for the past six years. The Sulphide Corporation has treated 1,176,934 tons of tailings up to June 30, 1912, under this license, from our dumps and our lead mill, yielding 445,299 tons of zinc concentrates at an average cost

of eight shillings and five pence per ton and an average profit of eleven shillings and one penny per ton, realizing thereby a total profit of £650,153. These operations were carried out at Central Mine, Broken Hill, Australia.

Cross-examination:

I am a partner in the firm of Gibbs, Bright & Company, which firm and its London House, Antony Gibbs & Son, are very large stockholders in the Sulphide Corporation, and both firms hold shares in Minerals Separation, Ltd. None of the individual members hold any shares or are directors of Minerals Separation, Limited and they have never been such directors. (443—366)

497 *Testimony for Complainants of Arthur Weaver Wincey.*

LONDON, ENGLAND, September 5, 1912.

Direct examination:

I am thirty-three years of age, a resident of Broken Hill, Australia. I have been since June, 1906, superintendent of the Sulphide Corporation's mill at Broken Hill. I was last at the plants of the Sulphide Corporation at Broken Hill on July 24, 1912. I produce and identify four photographs of flotation concentration plant of the Sulphide Corporation taken the day before I left Broken Hill (introduced in evidence as "Complainants' Exhibit Sulphide Retreatment Plant," Nos. 1, 2, 3 and 4, respectively). Photograph No. 1 represents the flotation plant for retreating slime concentrates derived from previous treatment. The plant is shown empty. Photograph No. 2 shows the same plant under working conditions. Photograph No. 3 shows the same plant with the spitz boxes full of water, as usually left after an operation, and particularly shows the paddles and also the level of the water in the various boxes. Photograph No. 4 is a front view, like No. 3, except with the plant at work. The paddles shown in photographs 3 and 4 are for the purpose of scraping off the concentrate practically free from solution. The concentrates are in the form of a thick spongy froth.

The only other flotation plant in operation at the Central Mine of the Sulphide Corporation when I left there in July, 1912, was
498 the plant of the Zinc Section, which treats the tailings and slimes as produced from the lead mill. This Zinc Section plant is essentially the same in construction and operation as the retreatment plant shown in the photographs. (444—367)

In the Zinc Section plant the pulp is delivered to No. 1 mixer, where sulphuric acid and steam are added. In No. 2 mixer oleic acid or other suitable agent is added and the pulp is violently agitated. There are eight mixers in this plant and six spitz boxes. In the mixers the pulp is violently agitated. The first two mixers are run at a slightly higher speed than the following six. The

pulp from No. 2 mixer flows through an opening into the No. 3 mixer, and from No. 3 mixer into No. 1 spitz box. From No. 1 spitz box the concentrate is scraped off by the paddles, which are like those shown in the photographs. The pulp containing the zinc and tailings sinks to the bottom of the flotation spitz boxes and is conducted through a pipe into No. 4 mixer. From No. 4 mixer it is delivered into No. 2 spitz box and this operation continues until we reach No. 6 spitz box, where the tailings are drawn out and run to the residue vat. The concentrates from 1, 2, 3 and 4 spitz-boxes are run into the concentrates settling-box. The concentrates from 5 and 6 spitz-boxes are returned by an elevator to No. 1 mixing-box, where they are retreated with the original pulp. The concentrates from the concentrates settling-box are then treated in a deleading plant. The slimy water from this deleading plant is de-
499 livered as feed for the retreatment flotation plant.

The standard oily mixture used at the plant is composed of eucalyptus oil and oleic acid in the total proportion of .9 to 1.3 lbs. per ton of ore. The consumption of sulphuric acid per ton of ore is somewhere in the neighborhood of 19 lbs.

I started in the flotation concentration work about June, 1906, and have been working with it ever since. When I started there were accumulations or dumps of tailings (445—368) of from half to three-quarters of a million tons, dumped from previous lead milling operations. These tailings have all been treated in the Central Mine in one or another of their flotation plants. (The witness then identifies the various agitation-froth flotation plants described in the testimony of Mr. Chapman.) The process in all these plants has been exactly the same, only in the later type modifications have been introduced to enable the saving of labor and better supervision.

The thickness of the froth on No. 4 spitz-box, as shown in photograph 2, is about seven inches. In photograph 3 the water in the last spitz-box is shown as overflowing for the purpose of showing that it may overflow there without overflowing in the other spitz-boxes. The liquid in all of the spitz-boxes is connected by the openings from spitz-box to spitz-box, so that the fluid level is substantially the same in every spitz-box of the series.

Cross-examination:

The ore treated by the Sulphide Corporation at Broken
500 Hill, Australia, contains an average of about 1% of calcite, sometimes exceeding 1% and sometimes running less than 1%.

I have no idea what is the maximum which occurs during these variations, as it may vary from time to time during the same shift, and, as our samples are only taken from the shift's run, I could not say what the maximum or minimum would be, but the average is very constant. The maximum amount of calcite that I have ever known upon any occasion to be contained in the material passing through the Zinc Section plant, as I remember, would be about 1.2% of carbon dioxide in the ore, which would be about 3% of (446—369) calcite.

49 X Q. Can you state about how long a time interval elapses between the entrance of the pulp into the first mixer of the Zinc Section Plant and its final departure from the same?

A. I have made tests to determine this data and found that the first particle coming through will make the trip in about five minutes, but some will continue to come through after ten minutes. That is to say, in running the mixers empty and feeding in a few bags of tailings some will come out of the exit in five minutes and some will continue to come out after ten minutes, so that an average between these would be approximately near the mark.

The ore treated at the Zinc Section plant of the Sulphide Corporation contains from 17% to 31% of zinc. The agitation
501 boxes used at the Zinc Section are 3 feet square by about 5 feet deep. The agitations are revolved at from 265 to 270 revolutions per minute. In the operations of the plants in Australia to which I have referred, I have never used any of the petroleum oils, although I believe they have been tested on plants which I have been away from at the time. (447—370)

Testimony for Complainants of John Ballot.

LONDON, ENGLAND, September 5, 1912.

Direct examination:

I am the same John Ballot who has heretofore testified in this suit, at the request of defendant's counsel, as a witness for the defendant.

At the latter end of January, or a very early date in February, Mr. T. J. Hoover himself prepared the pencil drawings in his room at our offices from which "Complainants' Exhibit First Tracing Slide Machine" is a tracing, after the invention had been disclosed to him by Messrs. Sulman and Picard. This was certainly before the first appearance of the defendant at the offices of Minerals Separation, Limited.

No dividend has been paid by Minerals Separation, Limited, although substantial income has been earned. The policy of the Board has been to use the funds for the general betterment of the company's processes, also for introducing the use of the processes to mine owners and others in different parts of the world as well as to seek investments themselves by the way of acquiring raw
502 material, that is to say, mines or dumps of tailings or ores suitable for use thereby, and also to defend the company's patents from attack on third parties as well as to protect the company's interests against infringement by third parties. For these reasons the funds of the company have been nursed so as to leave it in a strong position financially to carry out the same.

I have had prepared and produce the following statements, which are self-explanatory. (448—371)

The statements produced are put in evidence with the following titles:

"Complainants' Exhibit Statement of Expenditures in Agitation-Froth Process";

"Complainants' Exhibit State- of Expenditures by American Syndicate in Agitation-Froth Process";

"Complainants' Exhibit State- of Tonnage Treated by Agitation-Froth Process at Broken Hill, Australia";

"Complainants' Exhibit Statement of Profits and Royalties on Agitation-Froth Process"; and

"Complainants' Exhibit Table of Sulphide Corporation Operations with Agitation-Froth Process."

The statement of expenditures of American Syndicate does not include any litigation expenses, but, exclusive of litigation, it represents the expenditure in the effort to introduce the agitation froth process into use on the North American Continent.

The financial straits of the Zinc Corporation, as testified to by Mr. H. C. Hoover, were not related to their first test and rejection
503 of the Minerals Separation process. They were in financial straits as early as July, 1906, when Mr. H. C. Hoover submitted certain figures to me with a view to getting our group to finance this corporation. By reason of the liabilities which that corporation had incurred, and which amounted to a very large sum, no business resulted with us. In April, 1907, they were in financial straits again and during April had to raise a temporary loan of £50,000, in which one of our directors, Mr. Curle, and myself took a participation of 5%. £30,000 of this loan was called for and our final participation amounted to £1,500.

(The attention of the witness was called to the following testimony of the defendant, James M. Hyde:)

"Further, that a year might indicate to us that it was not wise to attempt to do business (449—372) together further, and that during the year I should come into possession of an inheritance which, supplementing my own earnings and savings, would permit me to operate independently upon a modest basis."

I distinctly remember the defendant mentioning to me personally, and he may have done so in the presence of other members of the board, that he expected such an inheritance, but the reason why he did not wish to extend his agreement beyond one year was principally due to the fact that some high authority of the American Government Education Department had offered him some position on that Department, exactly what it was I do not remember, and that if that position were given to him, he would prefer to accept
504 such an appointment rather than to continue a mining practice, as educational work was more agreeable to him; but I certainly do not remember as one of the reasons given that the inheritance would permit him to operate independently in mining business. By mining I mean mining and metallurgical business.

No cross-examination.

The apparatus marked for identification "Sulman & Picard Slide Machine" is offered in evidence and marked "Complainants' Exhibit Sulman & Picard Slide Machine." (450—373)

Testimony for Complainants of Hugh Fitzalis Kirkpatrick-Picard.

LONDON, ENGLAND, September 5, 1912.

Direct examination:

I am the same Hugh Fitzalis Kirkpatrick-Picard who has heretofore testified in this suit, at the request of defendant's counsel, as a witness for the defendant.

I made the apparatus "Complainants' Exhibit Sulman & Picard Slide Machine" in my own private work shop at my house, in the autumn of 1909, certainly not later than November or December of that year. This was the last apparatus of this general character made by me and satisfied me as being suitable for the purpose for which it was designed. Prior to making this machine, I made three or four different machines of the same general type, which had the some object in view, that is, the efficient cutting off of the
505 froth from the gangue. When this apparatus was completed, we made several tests in our laboratory with it and after proving that it worked to our satisfaction we asked Mr. Ballot to come and see it. He did so and then sent Mr. T. J. Hoover to inspect it. This would probably be in January, 1910. After Mr. Hoover had seen it, I went to his office and gave him my original drawing from which this machine was built. Mr. Hoover said that he would use this as a basis for a standard machine for use in Minerals Separation Company's tests.

Cross-examination:

I never had any communication with Mr. Hoover other than as above stated as to the design of a suitable laboratory testing machine, and the type evolved, as shown by this exhibit Sulman & Picard Slide Machine, was entirely the work of Mr. Sulman and myself, without suggestion of any kind from anyone else. (451—374)

The following documents marked for identification are put in evidence, each being entitled with its identification mark, preceded by the words "Complainants' Exhibit":

Sulman & Picard Report, March 25, 1903;
Sulman & Picard Report, May 5, 1903;
Sulman & Picard Report, September 24, 1903;
Sulman & Picard Report, November 19, 1903;
Sulman & Picard Report, March 4, 1904;
Sulman & Picard Report, April 19, 1904;
Sulman & Picard Report, May 2, 1904;
506 Sulman & Picard Report, May 18, 1904;
Sulman & Picard Report, February 17, 1905;
Sulman & Picard Report, February 21, 1905;
Sulman & Picard Report, March 3, 1905;
Higgins' Report, March 2, 1905;
Higgins' Report, March 16, 1905;
Sulman & Picard Report, May 3, 1905;

Sulman Drawing Accompanying Report, May 3, 1905;
Sulman & Picard Report, February 24, 1910;
Nutter Report, December 3, 1910;
Assignment Froment to Ballot, November 17, 1903. (452—375)

Testimony for Complainants of A. Howard Higgins.

NEW YORK, N. Y., November 6, 1912.

Direct examination:

I am the same A. Howard Higgins who has heretofore testified in this suit, at the request of defendant's counsel, as a witness for the defendant.

An apparatus has been made as a reproduction of the Froment apparatus received by Mr. John Ballot and his associates in the latter part of the year 1903. This apparatus is almost an exact copy of the original received with one exception. The mixer vessel was possibly one or two inches less in diameter and had no covers. The agitating mechanism is, as far as I can remember, an exact copy, as is also the vat with coil containing the rake.

507 Cross-examination:

I think the number of teeth upon the different gears in the original Froment apparatus was about 2 to 1. I base this statement upon the turbulence of the liquid when operating the machine. I have no record of the speed at which I rotated the beaters in my trial of the original Froment apparatus, but I think it was between 300 and 400 revolutions per minute. I would not describe the original Froment apparatus as consisting of stout wire somewhat like a gridiron, although a witness in this suit has so described the two beaters. My recollections in this matter are quite clear, the beaters being, as I have said, an exact reproduction. I saw no drawings of the Froment apparatus at the time I tested the original Froment machine. At that time I did not see any written description of the machine or of the mode of operating it. (453—376)

I have de-slimed some Broken Hill ore, which had been crushed to pass through a 60-mesh screen.

The apparatus produced is put in evidence as "Complainants' Exhibit Reproduction of Froment Mixer" and "Complainants' Exhibit Reproduction of Vat with Coil." (454—377)

Testimony for Complainants of Adolf Liebmann.

NEW YORK, N. Y., October 14—November 18, 1912.

Direct examination:

I am sixty years of age, a consulting chemist, and resident of Weybridge, near London, England.

508 I am a Doctor of Philosophy and Master of Arts of the University of Bonn, Germany. I studied mineralogy under Prof. Von Rath. I studied physics under Prof. Clausius, the

famous scientist who evolved the mechanical theory of heat. I studied chemistry under Prof. Kekule, who is considered by many to have been the most eminent chemist of the last century. I was for five years assistant to Prof. Kekule. I am a member of a number of learned societies; of the German Chemical Society, of the German Society of Applied Chemistry. I am a member of the Society of Chemical Industry, the corresponding English Society. I am a member of the Royal Institution of England. I am a Past Lecturer of the School of Technology of Manchester, and am a member of an advisory committee to the Council of the University of Leeds. Since 1884, that is for twenty-eight years, I have been consulted with regard to chemical and physical problems, and have frequently been called as a witness to testify before the courts in matters relating both to chemistry and physics, in England, Germany and the United States. I am retained by a number of the very largest manufacturing concerns in Germany, England and Canada, in matters referring to chemistry and to physics. Ever since 1881 I have been engaged in the solution of technical problems both practically and theoretically. (455—378)

I have read the patent in suit No. 835,120 and fully understand it. I have read the testimony of the defendant James M. Hyde and of the defendant's expert Dr. Eugene A. Byrnes. I have
509 devoted about three months to the study of the patents mentioned in this suit and to the issues raised by them. Having carefully considered the objections raised by the defendant and disclosed in the different patent documents, I have formed the opinion that the invention now in controversy is an entirely novel, ingenious and unexpected process, which by its great simplicity fulfills the most ideal demands of ore concentration.

All former efforts to make use of oil in ore concentration consisted in making use of the attraction of oils for minerals and either in separating them by producing a buoyant mixture of oil and minerals, which being lighter than water are capable of floating on water, or in kneading the fine particles of minerals together by oil in such manner that they form large aggregates of minerals in oil which would settle, in consequence of their heavy weight, below the gangue and could be easily separated from it. Later attempts have been made to lift such aggregates by the generation of gases, or by blowing air through perforated pipes into the mass formed by the previous process, to the surface of the solution of water, and to collect the mineral in this way. In all these attempts the character of the minerals was lost. It was the character of the oil which predominated and completely buried the properties of the minerals. In other words, it was a mixture of minerals with oil, either in large quantities or in smaller quantities, which was produced by embedding the mineral in oil. (456—379)

510 The present invention differs essentially from all previous attempts. It is true that oil is one of the substances used, but it is used in such quantities which were never heard of, and it produces a result which was never obtained before. The result is that the minerals are obtained as a froth of a very peculiar charac-

ter. It is a froth consisting of air bubbles, which in their covering film have the minerals embedded in such manner that they form a complete surface all over the air bubbles. The remarkable fact with regard to this froth is that, although the very light and easily destructible air bubbles are covered with a heavy mineral, yet the froth is stable and utterly different as far as this property is concerned from any froth known to me. It appears as if the minerals were protecting the tender air bubble like an armor, and, instead of destroying it, were actually guarding it. The froth has a long life. One feels tempted to say it is permanent, at least as far as metallurgical operations are concerned. I have myself seen a froth standing for twenty-four hours without the least change having taken place. Further, a very striking difference between the previous processes and the process of the patent in suit is the difference between failure and success. This I will explain more fully hereafter.

The simplicity of the operation as compared with the prior attempts is startling. The whole work which has to be done is to add an infinitesimal quantity of oil to the pulp, to which one may or may not add an acid, agitate from two and a half to ten minutes,
511 and collect the froth which appears after a few seconds collecting on the surface. The froth contains a large percentage of the minerals present in the ore. For continuous work nothing is required (457—380) but an agitator, which is connected with another vessel, such as a spitzkasten, from which the concentrates overflow as a thick froth.

The appearance of this froth is most remarkable. The color and luster of the minerals is the same as if no oil were present. It is very strong, and even if the top layer is destroyed, the underneath layers will bear it without being destroyed themselves and carry the mineral fallen from the top layer. No air bubbles are visible—nothing but the uninterrupted covering formed by the concentrates.

I should like to add that I shall make a more detailed description of the invention and differentiation from prior processes when the patent in controversy and the specifications offered as objections and anticipations are discussed.

The Bradford patent No. 345,951, issued July 20, 1886, discloses a process for collecting losses occurring on Rittinger tables, Frue vanners and jigs. It depends on the well known phenomenon of skin flotation. No oil is used and no agitation in the true sense of the word. The drawings represent the old and well known apparatus above mentioned, with the additional plant proposed by the inventor to carry out his invention. Fig. 2 illustrates a Frue vanner, but the drawing is a diagrammatic sketch and well known details are not shown in the drawing.

512 Bradford's invention is not an oil process. No slimes can be treated by it. The phenomenon used depends on skin flotation, or surface tension, while the agitation froth of the patent in suit depends on the fact that the froth produced is lighter than water and follows the natural law that bodies lighter than water will float on the surface.

The Carrie J. Everson patent No. 348,157, issued August 24, 1886,

discloses a process for the concentration (458—381) of ores by means of oil and acid, but the inventor believes that its commercial value is probably restricted to ores bearing precious metals, such as gold, silver and copper. But even this limited forecast proved to be too sanguine, as it has never come into practical operation. She has devised two ways of carrying her process out. One way is described commencing on page 3, line 1, to page 2, line 74. This is described as a laboratory experiment. It produces a mass from which the sand or quartz is removed by washing. I have carried this out in experiment and I have come to the conclusion that it is an utterly impossible process for the treatment of large quantities. The result of the incorporation of the ore with the oil and acid is a kind of pudding. There is no similarity of this process and of its result with the agitation froth of the patent in suit. I notice in Dr. Byrnes' evidence that he is silent about this part of Everson's patent, and he apparently has come to the same conclusion that I have,
513 namely, that this part of Everson's invention has nothing to do with the process of the patent in suit and that it is an impossible process.

In the second mode described, the proportions between ore and oil are about 100 of ore to 20 of oil, and the principle which guides the inventor and on which the invention is based is that the sand must be heavier than the mixture of mineral and oil. After the oil has been incorporated with the ore, the acidulated water is added and the mass is thoroughly agitated, and the concentrates are washed out by a constant overflow of water. I have carried this out in experiment by incorporating 63 cc. of Texas fuel oil with 300 grammes of Broken Hill ore, adding the paste thus produced to 2,000 cc. of water containing (459—382) .75% of sulphuric acid. The whole mixture was contained in the apparatus known as the slide machine and was thoroughly agitated for six minutes and the agitation was then stopped. Oil containing minerals and some air bubbles were both at the top and at the bottom of the water. The mixture was then slowly agitated and allowed to flow into a spitzkasten, in which at the same time a gentle up-current of acidulated water was maintained. The oily liquid flowing on the surface which contained some of the mineral was collected by overflow. The tailings which sank to the bottom contained considerable quantities of minerals and oils. This process of Everson depends on the fact that a mixture of oils with minerals, if this mixture is lighter than the gangue, can be removed by overflow by means of an upcast of water
514 and thus separated from the gangue. It is from the results of my experiments an unsatisfactory process and my opinion of it is confirmed from the fact that the process has never been carried out in practice.

I am strongly of opinion that there is nothing in either of these processes which has any resemblance to the phenomenon first discovered and described in the patent in suit. Everson's processes both deal with oil in considerable quantities. The cost involved is large. The patent in suit uses microscopic quantities of oil which cannot be discovered in the final result unless by chemical analysis

and examination. The result, as I have mentioned above, is an absolutely new phenomenon, of which I could not find anywhere in literature an analogue. According to my knowledge, it is the first time that a froth is described which behaves like a bubble of air enclosed by a sheet of metal. It actually has the properties of an air bubble enclosed in such a manner. (460—383)

I agree with Dr. Byrnes that the Everson patent contains a novel disclosure of the fact that acid emphasizes the quality of the gangue to resist being coated with oil.

Dr. Byrnes describes an experiment which is meant for an illustration of Everson's invention as revealed by the second process. The description of the mixture of oil and ore as having the consistency of damp sand is not very fortunate. The mixture of oil and
515 sand forms a pasty mass, according to my experience. The experiment was carried out in a slide machine at a temperature of 27° Centigrade (80.3° Fahrenheit). There are no instructions whatever in Everson's patent that such a temperature should be used. I consider it unfair to the patentee to introduce any variations when testing the process of a patent. Dr. Byrnes then continues to say that, after agitation, he obtained a good froth. I deny that in carrying out Everson's invention as described a good froth is obtainable. It is a magma consisting of oil, some water, minerals and gangue. He then removes the alleged froth, but does not say how; it is, however, quite clear not by the method suggested and specified by Everson. Then he repeats his process of agitation and collection of so-called froth nine times. There is no description of such a process to be found in the patent. Everson's invention depends on the fact that the mineral and oil must be lighter than the gangue. After the removal of the first mixture of concentrates and oil, which, of course, is bound to effect the removal of the largest amount of oil present, the condition of the remaining mineral was surely different from that condition which forms the basis of Everson's invention. Dr. Byrnes' condition of mind when carrying out this experiment is quite comprehensible. It is frequently found and it originates (461—384) from the fact that a man cannot put himself back to the time when a certain invention was made.
516 Dr. Byrnes treated Everson's patent not as having been made in 1885, but in 1912. By repeating the agitation nine times, removing after each agitation the oil and what it may have contained, he may finally have come to conditions in which very little oil was mixed with the minerals. The result of this experiment was a collection of concentrates weighing 144 grams. As no assay of this concentrate was produced, the figure will tell us nothing.

I made an experiment to carry out the process of the Everson patent. I mixed thoroughly 450 grams of defendant's ore finely crushed with 90 cc. of crude petroleum. The pasty mixture thus produced was agitated with 1600 cc. of water acidulated with 3 cc. of sulphuric acid. After thorough agitation the mixture was run into a washing-out vessel and the concentrate removed by a constant overflow of water. The tailings were allowed to run away from the bottom. The concentrate weighed 256 grams. An assay showed

it to contain 12.1% of zinc, and the zinc contents contained in the concentrate were therefore 31 grams.

In summing up Everson's invention, I say that it contains an important discovery, namely, the utility of acid in removing the gangue from the oil. It reveals the first attempt, which, although unsuccessful, is still of great historical interest, of trying to solve the problem of ore concentration by a combination of oils and acid. It took twenty years more before it was finally solved and an enormous amount of intermediate work, which, although, perhaps, in
517 some instances an advance on Everson, yet was still far away from the final solution of the problem.

The article published in "The Daily Herald Democrat" (462—385) of Leadville, Colorado, on Wednesday, October 30, 1889, appears to be a description of an experiment according to the Everson process. With the exception of the use of heat, which assisted in dividing the oily layer from the water, and the use of a specific apparatus containing arastra-like fans which give a slow agitation, nothing new is disclosed in the "Daily Herald Democrat" article that was not revealed in the Everson patent. It is stated that the ore treated was an ore containing silver, and a concentration of the silver particles was obtained. It is not as clear a description as the Everson patent and conveys much less information than the patent. I conclude by saying that no possible information is contained in this document which could lead anybody anywhere near the invention of the patent in suit, and that it is quite impossible, according to this description, to produce by agitation any true froth and much less the agitation froth of the patent in suit.

The process described in "The Engineering & Mining Journal" of November 15, 1890, seems again an application of the process of the Everson patent, with slight modifications. Black thick oil is described as having been used. To make a proper mixing with black thick oil, a rather larger quantity must be used than
518 would be necessary if petroleum was used, it being remembered that the use of petroleum was described in example No. 2 of the Everson patent. The statement in the article that "a thick scum of sulphurets rose to the surface and was skimmed off" could only mean that the layer of oil containing minerals appeared on the top of the water.

The description is very scant and practically no details are given. It would be impossible to draw from it (463—386) any other conclusion but that it was a performance of the Everson patent process with some slight modifications, a recovery of minerals from an ore by oil flotation. If it is contended that this article discloses the agitation froth phenomenon and the process leading thereto, then I say that it does not disclose anything of the kind and that it does not even get us any farther than the Everson patent, with the exception that it contains a description of the use of hot water. The experiment strikes me as a description of a laboratory test.

The Hebron & Everson patent No. 471,174, issued May 17, 1892, discloses an invention which consists in forcing buoyant material into alleged pores of minerals, or making such materials adhere

to the irregular surface of the minerals, in such quantities that the particles will float on the surface of fluid for sufficient time to be separated from the gangue. A number of substances are described as suitable for the purposes of the invention, charcoal, lamp black, bark, moss, cotton, wool, sulphur, aluminum hydrate, sodium oleate, metallic sulphates, etc. The carbonaceous
519 substances (charcoal, lamp black, etc.) are specially recommended for the reason of their cheapness, their positiveness of action, and their destructibility in the furnace. The quantity of buoyant material it is said should be equal in bulk to the bulk of the mineral contained in the ore. The use of oils is discarded. The invention discloses an attempt to reduce the specific gravity of the minerals by attaching to them substances of much lower specific gravity; in other words, an attempt to reduce the falling power in water of minerals by the adhesion of dry powdery substances which are lighter in specific weight. It has nothing to do with the patent in suit. (464—387)

The Hebron patent No. 474,829, issued May 17, 1892, discloses a process stated to be an improvement on the process of Hebron & Everson described in patent No. 471,174, this patent being identified by the serial number of its application 404,400. As stated, the improvement consists in obtaining a greater buoyancy of the buoy stock by preliminary treatment with heat and under a vacuum. The invention is not an oil process for the concentration of ores. The use of oil is an impossibility. It is an attempt to increase the buoyancy of the result of the earlier patent by putting more buoyant material into the mineral than could be done by the process of patent No. 471,174.

The Everson patent No. 348,157, the Hebron & Everson patent No. 471,174, and the Hebron patent No. 474,829 are highly interesting. The first invention was made in 1885. It was a
520 process depending on oil and in which oil was used in large quantities. Two attempts at least were made to introduce the invention into practice, one in 1889 and the other in 1890. Both apparently failed, and rightly so, because the process as revealed in Everson's specification could never be a practical process. It may have been a germ, if properly further developed, which might have led to the Elmore process, or even to the Cattermole process, but Everson, being an inventor and therefore imaginative, discarded oil and turned her versatile mind to other bodies, dry substances, for the production of buoyancy in the minerals. Thus she arrived, in collaboration with Hebron, at the invention which is disclosed in patent No. 471,174. Then we have the Hebron patent, which was granted to Carrie J. Everson as one of the assignees, stated to be for an improvement on Hebron & Everson. The study of this series in their sequence shows an inventive mind originating a (465—388) new idea, the use of acid in the concentration of ores with oil. It shows the struggles of the inventor to induce the public to accept an unsuccessful, and therefore useless, process. It shows that she recognized the uselessness of her oil process, but that this failure does not discourage her; her inventive

mind turns into other roadways, abandoning apparently as impossible the earlier direction. It is clear, from the history told by these documents that she did not, with all her efforts, invent or discover a successful oil process of ore concentration; that she was even very distant from Cattermole's invention, and that to allege
521 that her unsuccessful process was an anticipation of the process of the patent in suit, the agitation froth process, is utterly absurd.

The Hockley patent 466,753*m* issued January 5, 1892, contains a disclosure of the well-known fact that finely divided gold and silver will float on water. By the introduction of an up-current, the mineral is carried to the surface of the liquid, and, if exposed to air, then the phenomenon of surface tension will come into play to prevent the minerals from sinking down.

The Rouse patent 469,599, issued February 23, 1892, does not involve the use of oil or acid, and the foam mentioned in the patent is the ordinary every-day life froth which collapses, one might say, as soon as it is produced.

The Francis Elmore patent No. 676,679, issued June 18, 1901, discloses a process of separating minerals from gangue by oil flotation. It depends on the fact that by immersing the ore in oil, only the minerals are taken up by the oil if water be present, and the gangue remains behind. That is the broad principle. It is, however (466—389) quite evident from the description that the separation is not a sharp one and that the gangue, after the first treatment with oil, contains still considerable quantities of the values and that new additions of oil to the tailings remaining after the first treatment have to be made and the extraction repeated. The process depends on flotation by specific gravity. The pulp, which ought to be a freely flowing mixture, has a quantity of oil added
522 and has to be agitated by slowly revolving agitation in such manner that the oil does not break into small globules. The minerals will be enclosed by the oil and the oil will float by buoyancy. This process depends on the well-known fact that you can reduce the specific gravity of a heavy substance by mixing with a light one. I may remark here that it is a process not suitable for the treatment of slimes. The patent recommends the use of thick oil. I have made several experiments with regard to this patent and I find it correct that the principle of this invention is flotation by specific gravity. I need scarcely add that the process of this patent differs absolutely from the process of complainants' patent in suit, that it depends on utterly different physical laws, and that, as regards its economy and utility, the Elmore process and the process of the patent in suit cannot be compared with each other. The Elmore process is expensive and complainants' process, as far as I know, is the cheapest in existence.

The Alexander S. Elmore patent No. 689,070, issued December 17, 1901, announces the discovery that in some cases a slight acidulation enhances the selective action of oil in a mixture consisting of an ore pulp and oil, from which the mineral is to be separated by oil flotation. The process is a development of the process discussed be-

fore (467—390) and described in patent No. 676,679. The development consists in making use of Everson's discovery,
523 that the presence of acid prevents oiling of the gangue. The patentee mentions as suitable acids oleic acid and sulphuric acid, and states that the quantity to be used need not exceed often one five-hundredths part of the volume of oil or water employed in the operation. The remarks made about the patent mentioned before, No. 676,679, apply equally here.

The first Delprat patent, No. 735,071, issued August 4, 1903, depends for the separation of the mineral on the possibility of a gas which is generated in the mixture of a sulphide ore with water by an acid, attaching itself to the mineral and lifting the mineral to the surface whilst the particles of the gangue fall to the bottom of the fluid. The inventor says that in order to facilitate the process suitable salts are added to the solution to increase its specific gravity. The acid used and claimed is nitric acid, and the salts recommended to be added to the solution are nitrates, and the specific gravity of the solution should be 1.4. The inventor states that the gas is produced by the action of nitric acid on the sulphide. To produce a gas in this way is chemically impossible. But, however that is, the process as described has no resemblance whatever with the process of the patent in suit. It does not depend on the presence of any oil. It does not depend on agitation. (As a matter of fact, it is clear from the drawing of the apparatus that there is no agitation whatever, that the mass cannot be agitated.) It is simply the lifting of a particle or of particles of mineral by a gas bubble. If
524 a gas bubble should burst on its journey to the surface, the mineral would fall down again, and if a gas bubble should burst while on the surface, the minerals (468—391) would likewise fall to the bottom. There is no mention of the formation of any froth in the patent and neither the process nor the result described therein has any resemblance whatever to the process and the result of the patent in suit.

The second Delprat patent, No. 768,035, issued August 4, 1903, discloses a process which is the same as of the first patent, except that sodium sulphate and sulphuric acid are used in place of nitrate and nitric acid.

I should add as to both these Delprat patents that no oil whatsoever is used and that heat is relied upon, in the second patent the heat being just below boiling point.

The Potter patent No. 776,145, issued November 29, 1904, discloses a process similar to the Delprat process, involving the lifting of minerals by means of gas bubbles generated by sulphuric acid and without the use of any oil. Heat is to be used, and also agitation, but it is clear from the drawing and equally so from my experimental experience that the agitation must be very slow and that brisk agitation will defeat the object which the inventor contemplates to achieve, and the "pasty mass" (page 1, line 43) would by brisk agitation be sent to the bottom. I notice a statement in claim 3 that the separation of the minerals from the ore is due to
525 bubbles of sulphuretted hydrogen formed by the action of the acid on sulphides. Although a smell of sulphuretted

hydrogen can be observed during the performance of this process as well as of the second process of Delprat, the lifting power is due, in my view, to carbonic acid, generally. There are in most ores carbonates present and the action of sulphuric acid on carbonates at Potter's or Delprat's temperature is to liberate carbonic acid from them. The gas bubbles are continually bursting and the (469—392) destruction of each bubble involves the return of the mineral to the bottom of the vessel. Potter does not use any oil, he does not introduce by brisk agitation air into the pulp; such an agitation would be absolutely fatal to Potter's process and would lead to no results.

I have made a number of experiments to study the result of the Potter process. I observed that the lifting was always due to gas bubbles attaching themselves with one part of their surface to mineral particles, whilst the remainder of the bubble was usually clear. I always noticed that a part of the film was not covered. These loaded gas bubbles were very tender and frequently burst and the minerals sank again. If the stirring was anything but very slow, nothing would rise to the surface. I made one quantitative experiment. 400 grams of Broken Hill tailings, 1000 cc. of water containing 2½% of sulphuric acid were heated to 85° Centigrade and the mixture was slowly stirred. After two minutes' stirring,
526 the minerals which had appeared on the surface were taken off, filtered, dried and weighed. The weight was 37 grams. The residue which remained after the froth had been removed was freshly acidulated with sulphuric acid, but so little minerals appeared on the surface that the quantity was not sufficient for further assay.

Dr. Byrnes' statements in connection with the character of agitation disclosed in this patent are absolutely incorrect, and a meaning is introduced which is not contained in the specification, and a fact is stated which is equally absent in the description. Dr. Byrnes says:

"The free use of an agitator of this type causes the solution to become thoroughly aerated and impregnated with fine air-bubbles."

I cannot find any such statement in the specification, but (470—393) from my experience I say deliberately that, if such agitation were used in connection with the Potter process, the result would be nil. The words actually used by the patentee are "The stirrers are then freely used," which, when interpreted with Figure 1 of his patent clearly show that he means "freely" in the sense of continuously, simply bringing mineral particles continuously from the middle of the ore to the top, so that they can rise to the surface after the attachment to gas bubbles. If the agitation were used which Dr. Byrnes attempts to read into Potter's specification, the result would be nil, as I said before; in other words, nothing would
527 stay on the surface and the purpose of this invention, namely, the separation of minerals from the gangue, could not be achieved.

The Glogner patent No. 736,381, issued August 18, 1903, describes a process of separating graphite from a graphite ore having earthy admixtures only, and the process consists in adding to a mixture or, as the patentee calls it, a thin paste obtained from the graphite

mineral and three or four times its weight of water, one-half the quantity of petroleum of the amount of pure graphite contained in the graphite mixture, and stirring the whole thoroughly within a closed vessel. He defines what he means by thoroughly stirring, namely, having closed vessels suspended on chains which are moved by short shocks, thirty in a minute, one workman being able to attend four of these vessels. The graphite is taken up by the petroleum, whilst the earthy admixture remains in the gangue. The result, that is, the separation of the graphite from the ore, is due to the oil flotation; that is, the combined mixture of petroleum and graphite is lighter than water. Water is finely sprayed on (471—394) the surface of the petroleum to sink any earthy particles which might be present in the petroleum. The mixture of the petroleum and graphite is then removed and the shaking of the vessel is repeated, once, twice or oftener, each time after the addition of fresh petroleum.

The statements made by Dr. Byrnes as to the character of the agitation disclosed in this patent are particularly unfortunate,
528 in view of the very accurate description of the process contained in the patent. Dr. Byrnes calls 30 shocks per minute a strong agitation, which is not only designed to intimately distribute the petroleum throughout the pulp, but also to aerate the pulp and cause the oiled mineral to float to the top as a froth. What the patentee describes is that by his stirring the petroleum is broken up into small drops or perles and every particle of graphite, when touching them, is attracted, whilst the earthy particles, which have been saturated with water, before the addition of petroleum, remain completely neutral; that is, are not attracted by the petroleum. What is more, if the inventor had contemplated a froth process, he surely wouldn't have destroyed the object of such an invention by sprinkling water on the surface of the oil. Furthermore, this is a process which depends on the reduction of the specific weight of the substance by mixing it with a much lighter body. The mixture of petroleum and graphite is lighter than the water and floats on it. There is not a word in the specification referring to aeration, and what is more, there is no aeration. As to Dr. Byrnes' remarks, "Agitation by 'a strong rotating * * * movement' as suggested, is the type of agitation employed in the patent in suit to form a froth," I will say that I absolutely disagree with him and I feel (472—395)
529 compelled to add that it surprises me. To compare a stirring, which consists of thirty shocks a minute, with a brisk agitation used for the beating in of air into a liquid and operating at anything from 500 to 2000 revolutions per minute, according to the size of the apparatus used, does not appear to me permissible.

Glogner's process is practically identical with the first Elmore process, only he prefers to use petroleum instead of thick oil, and the result he obtains is identical with Elmore's result, namely, a recovery of the mineral by oil flotation. The similarity goes even farther. Like Elmore, he has to retreat his gangue and has to add new quantities of oil each time he repeats the extraction of the mineral. Elmore uses for mixing the oil with the mineral a rotating

motion, Glogner obtains the same rotating effect by sharp shocks. Neither of them uses any acid. There is absolutely no similarity between Glogner's process and the process of the patent in suit.

I have carried out the process of the Glogner patent, using the proportions and the conditions of experimentation described therein.

In a bottle 50 grams of ore containing 10% of graphite were made into a thin paste with 150 cc. of water, and 2½ grams of petroleum were then added. The mixture was shaken with short shocks about thirty to the minute. The top of the liquid was then a smooth surface of petroleum carrying graphite. Underneath were some little globules of oil carrying graphite. There was no froth
530 whatever. The gangue at the bottom was not quite cleared of graphite.

This experiment proves clearly and definitely that the theory advanced by Dr. Byrnes, namely: (473—396) "The waves formed by reciprocating the agitating vessels in short shocks would naturally entrain and intermingle with the pulp a large amount of air in the form of bubbles, just as an ocean wave entangles air and forms a floating froth or foam," is unsound and not in accordance with the actual facts. No intermingling with the pulp of a large amount of air in the form of bubbles takes place and no froth whatsoever is formed. This is equally true of the later remarks of Dr. Byrnes in fol. 1209:

"Glogner, 736,381, illustrates an oscillating agitating vessel, in which the mixture of ore-pulp and water is thrown violently against one end of the vessel, the wave falling back through the air, thus imitating the aeration and frothing produced by an ocean wave."

The Good patent No. 745,960, issued December 1, 1903, describes an apparatus for separating graphite and other materials. The patentee, however, mentions only graphite specifically, but does not define the other materials. The apparatus combines the functions for the performance of three processes and consists of three parts,

(1) A part which is for the separation of finer particles or flakes by skin flotation;

531 (2) Another part which is for the treatment of the finer particles which have been separated from the ore before it was submitted to the operation in the first part, together with the unfloated ore from the first treatment; the separation of the graphite from the ore being effected in this second part of the plant by oil flotation in a tank filled with boiling water. The coarser graphite, some oil and the sand remain at the bottom of this tank and are treated in

(3) A third part of the apparatus. The graphite in the mixture is crushed under water between two rotating wooden blocks, which have sufficient power for the crushing of the (474—397) graphite, but do not crush the sand. The mass is discharged over a screen into a trough. This screen retains the sand but allows the passage of the graphite. The latter is carried from this trough through a conduit into a settling tank. The processes carried out in the three divisions of the apparatus can only be

(a) Skin flotation,

(*b*) Oil buoyancy flotation,

(*c*) Grinding of only the graphite present in the mixture of coarse graphite and sand, separation of the so-ground graphite from the sand by a screen, and settling of the graphite in a settling tank.

No details whatever of the second and third processes are given, but, as far as their character can be determined from the construction of the plant, they can only refer to the use as mentioned under (*b*) and (*c*). The rotary agitator, described in part (2) of the plant, is used for a slow rotation to produce an effect similar
532 to the Elmore process. The oil flotation of the graphite takes place in the same tank in which the agitation takes place, and the oil containing the graphite is removed from the tank by pushing it over the lip of the tank into another tank. If there were brisk agitation, this would be quite impossible, as gangue would be likewise carried over and the very objects of the process defeated. As I have said before, the patent describes no process, at least as to parts (2) and (3) of the plant, but an apparatus. There is not a single word in it which would convey, even to the most acute intellect, the faintest idea of complainants' process and result, and even with our present knowledge it is absolutely impossible to carry out complainants' invention in this apparatus. (475—398)

The Wagner patent No. 373,113, issued November 15, 1887, describes an apparatus suitable for churning. Dr. Byrnes says, with regard to this patent:

"It is common in the production of butter to churn and beat air into the milk, the air diffused throughout it acting to throw down the curd and separate it from the butter."

This remark strikes me as being particularly inappropriate and unsuitable. The purpose of a churn for agitating cream is not to produce a butter froth in which air particles or bubbles are lined with butter. It is for the opposite purpose, namely, for producing the solid butter without air. I cannot pass over a remark which is contained in the same passage and which refers to the pro-
533 duction of an aerated soap suitable for floating on water. Again the use which Dr. Byrnes makes of this process does not apply to the process of the patent in suit. The soap is aerated in a liquid condition and the air is impregnated within the liquid soap. There is no separation as a froth of a heavy solid body by means of oil, and much less by minute quantities of oil and aeration.

I have read the article on "Flotant Soaps" referred to by Dr. Byrnes, which has just been handed to me for the first time, and I find that it is in agreement with what I have said.

A simple agitator called a "twirling fan" is shown for agitating the liquid soap. I do not think this would be a very good agitator for aerating an ore pulp. The same is true of the churn dashers of the Wagner patent.

The Stoveken patent No. 729,805, issued June 2, 1903, relates to the extraction of gold by the cyanide process from ores. The process involves a chemical reaction, namely, oxidation in the presence of a soluble cyanide, and the oxygen is supplied from its cheapest

source, namely, (476—399) from air, which is according to this process introduced by agitation.

In the cyanide process the only thing which is essential is that the air should be present and the only difference which can result from a different mode of introducing it can be slightly slower or quickened chemical action.

The Stoveken agitator, if constructed sufficiently strong
534 for the requirements of the agitation froth process of the patent in suit, could probably be used as the agitator.

The Kendall patent No. 771,075, issued September 27, 1904, discloses a process which is clearly an oil buoyancy process. The oil and graphite float on the water because they are lighter than water, just as cork floats on water. It has nothing to do with the process of the patent in suit.

I note that, although the defendant has put this patent in evidence, no witness for defendant has described it or referred to it.

The Cattermole patent No. 777,273, issued December 13, 1904, relates to improvements in the separation of the metalliferous constituents, that is, minerals present in ores, from the gangue, by means of the selective action of oil or certain coal tar products which are classified as oils. The invention depends on the following facts:

(1) An oil suspended in water has more or less selective action. It will coat the particles of metalliferous matters in preference to the particles of the gangue. In other words, the values will be coated with oil, the gangue will be wetted by the water.

(2) The presence of an acid in the mixture of the oil and the pulp will increase the selective action of the (477—400) oil and render it more marked and decisive.

(3) If the proportion of the oil is kept within reasonably low limits (the quantity of oil to be used in different cases may vary according to the nature of the ore to be treated and according
535 to the consistency and nature of the ore), and if the mixture of water, oil and ore is thoroughly agitated, the minerals become coated with oil and will adhere together, forming granules which, partly by reason of their gravity, partly on account of their bulk as compared with the individual mineral particles before this treatment, settle on the bottom of the agitating vessel when the agitation is stopped. The inventor has further discovered that this granulating action is facilitated if the oil, before the addition to the pulp, is emulsified with water containing a small amount of soap or other emulsifying agent.

On these three facts the inventor has based his very ingenious process for the separation of minerals from ores in the form of granules. The process is as follows: In a convenient apparatus the finely powdered ore is violently agitated, for instance, by a revolving stirrer, with the mixture of acidulated water and oil. By the process of agitation the mineral particles agglomerate together in the form of granules, which, when the agitation has ceased, will fall to the bottom of the vessel and which are so heavy that they can be removed from the sand in a simple way, by up-current of water,

which carries the sand and will not carry the granules along with it. The continuous process devised by the inventor is performed as follows: Four mixing vessels, which are in series and which are provided with stirrers, are filled with the ore pulp, the oil emulsion, and a small quantity of acid. The circuit is filled (478—536 401) with acidulated water and tuned up in such manner that the inflowing pulp and oily mixture will be corresponding to the outflowing water. Agitation is started and the pulp and oil mixture containing a small proportion of acid are allowed to run into the first mixer, from which it passes into the following mixers. The well-agitated mass, on leaving the fourth mixer, enters the vessel called by the inventor a classifier, which is provided with an upcurrent supplied through a pipe at the bottom through which acidulated water enters. The granules which have been formed in the agitator and separated in the classifier fall, in consequence of their greater falling power, with a certain quantity of the coarser gangue, to the bottom of the classifier, and are removed from there through a pipe into another agitator, whilst the lighter sands are carried away by the upward current and discharged into a settling tank. In order to separate the granules from the heavy sand, the mixture is further agitated in the mixer, of which there are two in series, and then pass into a second classifier and the falling power of the granules has been so much increased that the up-current introduced in the classifier will be regulated in such way as to be able to carry away the heavy sand, whilst the granules are discharged from the bottom of the classifier into another tank. The inventor states that this apparatus is only a type and serves as an illustration. It can be varied considerably and also the steps of the process may be varied. The mixers shown in the drawings are of a well 537 known type, namely, the cone or Gabbett type. They are shown as a diagrammatic sketch. In 1904, they were well known mixing and agitating devices. I have known them as "cone mixers" for many years before 1904. I knew them as cylindrical vessels with baffles. (479—402)

Cattermole has described in the text of his patent a rolling form of agitation as preferably to be used in some stages of the process to obtain a good granulation of the mineral, this rolling to be such as is had in cylinders or barrels. This appears at page 3, lines 46-50. This is not shown in the drawings. Of course, a cylinder or barrel could be used in place of any cone mixer which is shown, and it would be reasonable to put cylinders or barrels in place of the last two cone mixers. Indeed, it would be self-evident that this would be the place to use the rolling form of motion, as the first set of cone mixers could then be relied upon to intimately mix the oil with the mineral.

The proportion of oil used depends on its viscosity, the fineness of the ore and other factors, and on the consistency and size of the granules desired. The more oil used, the larger, softer and less numerous the granules. With 10% of oil to the weight of minerals, only a few pasty masses of oil agglomerated minerals will be generally obtained, and oil in excess of this quantity may cause all the

granules to coalesce into one soft mass. Cattermole recommends a quantity of oil between 4 and 6 per cent of the weight of the metalliferous mineral matter present in the ore, but this is
538 only a recommendation and a statement of what he has usually found to be necessary. It is clear from this description that a definite amount of oil to produce good granulation effects cannot be given, as the final result is determined by many factors which have to be first experimentally ascertained. No definite law of proportions can be laid down for this process, which is a process for the treatment of a large class of substances, each differing from the other in many ways, and is in that respect like (480—403) all other processes which are destined for the use of differently constituted compounds and not for the use of one individual substance. But the patentee has described his invention so well and exhaustively that a few experiments will suffice to determine the proper proportions suitable for a given ore.

The amount of emulsifying agent should be from 3 to 5 per cent of the weight of oil and as substances suitable for emulsifying processes, soap solutions of low alkalinity are recommended, but a large number of others are mentioned. A specially beneficial action in granulation is claimed for the acid liberated by sulphuric acid from the emulsifying agent.

The inventor describes further the process for the recovery of the oil from the granules. The oil is removed from the granules by agitating them with the emulsifying agent in a stronger or more active condition or proportion than is used for the emulsifying of the oil initially, and the stripping action of the emulsifying
539 agent is increased by attrition of the granules.

Where water is scarce, it is recommended that the wet crushed ore is allowed to settle and that only the wet ore is fed into the agitator, and in this way the circuit can be kept distinct from that of the mill water. Wherever an ore is intended after crushing for further treatment with water, it is usual to crush it wet, as in this way great inconvenience is avoided. That is not only so with ore, but with many other products.

The inventor gives warning that ores containing little mineral should be enriched for treatment by his process, in the following paragraph (Spec., p. 3, lines 34-43): (481—404)

"In certain cases, as where but little mineral is present in the ore, to increase the nucleating or granulating factor, pulverized mineral matter obtained in a previous operation or other matter having an affinity for oil from a different source may be introduced into the ore, or a portion of already granulated and separated mineral matter may be returned to maintain the necessary amount of mineral in the ore under treatment."

I have performed an experiment with the process of Cattermole patent 777,273. I took 500 grams of Broken Hill tailings, 30 cc. of an emulsion containing 10 grams of Texas fuel oil and an amount of resin soap (Primrose soap) of 3.3% of the weight of oil, and stirred

them violently in a cone mixer with 1500 cc. of water and
540 30 cc. of sulphuric acid. The mixture was allowed to flow whilst being agitated into the center of a vessel into which water was running up from the bottom and was running out at the top charged with slimy sands. The vessel had an opening at the bottom from which the minerals which were as granules quite at the bottom and the coarser gangue were emptied out and then put back into the cone mixer, from which, however, the baffles had been removed. They were there slowly rolled for about eight minutes and collected again as before. In this operation, part of the sand again was removed. The experiment proved the absolute correctness of the specification and of the description of the result.

The Cattermole, Sulman & Picard patent No. 777,274, issued December 13, 1904, describes a modification of the process of Cattermole patent 777,273, the modification consisting in the use of oils or oily substances which form combinations with alkalis, such combinations being alkiline salts, and in producing the fatty acids therefrom in situ. The apparatus used is identical with the apparatus (482—405) of the previous patent and the process equally so, with the exception that the fatty acid is produced, as stated, in situ. The result is agglomerated masses, or, as they have been called, granules. The patent is known as the Soap and Granulation patent.

The Cattermole, Sulman & Picard patent No. 788,247, issued April 25, 1905, includes the invention described in the previous pat-
541 ent No. 777,274. It broadly claims granulation by means of oily substances produced from the alkali salts in situ and the separation of the granules after their formation by a number of different methods, of which the method of the previous patent is one. There are several examples given, one of which is to remove the granules by flotation. A gas is generated in the mixtures and the bubbles on attaching themselves to the granules lift them to the surface, thus enabling the oil-coated aggregates to float by the phenomenon of skin flotation, and the substance will float sufficiently long for collection, even if the gas bubbles burst. Suitable sources for the generation of gases are suitable carbonates, which may be present in the ore, or added, or an easily decomposable sulphide, which on addition of mineral acids release the gases (in the one case carbonic acid, in the other case hydrogen sulphide) from the salts. Another mode described is to make the coated mineral aggregates adhere to metallic or other suitable surfaces, coated with similar fatty acids, that is, oily substances, and still another mode is to make the coated mineral particles adhere to suitable materials lighter than water, such as wood sawdust coated with similar fatty acids, that is, oily substances, by which process the minerals can be removed by flotation. Another feature of the process of this (483—406) patent and of the previous patent is the fact that the oily substances can be reconverted by treatment of the concentrates with an alkali into soluble soap solutions and these soluble soap solutions can be
542 used for the treatment of new quantities of ore, by which a great economy is effected.

The deciding phenomenon of this invention is the formation of a product which is heavier than water and gangue, that is, having such a physical character that it will actually sink in water. In the first two claims the method of separation is claimed generally and includes the process of removal of the two patents which have been discussed, No. 777,273 and No. 777,274. The second way of separation consists in lifting the aggregates of minerals up by gas bubbles, not as a froth, because there is no froth whatever, but by attaching themselves to the granules and making them rise to the surface. As soon as they are at the surface, the surface tension will keep them up long enough to allow of their collection, even after the gas bubbles have disappeared. No froth in the ordinary sense, I should say, is formed, but certainly nothing which has any resemblance to the agitation froth of the patent in suit. I repeat what I have said before, that the agitation froth of the patent in suit is a froth consisting of air bubbles which are absolutely covered by an armor of mineral particles, in which a clear film surface of the gas bubble is quite absent. It is a stable compound. In the flotation of the products of the process of the present patent, gas bubbles may support one or several aggregates of minerals, but there is regularly a clear space left in the bubble and the bursting of the bubble is of frequent occurrence. The two phenomena have no
543 similarity with each other. (484—407)

The Sulman & Picard patent No. 793,808, issued July 4, 1905, is another invention for the separation of oiled minerals by the skin flotation process, and there are several ways described to carry the invention into effect. The first step consists in adding such a proportion of oil to a pulp as will produce aggregation of minerals in the oil which are heavier than water, or, as the inventors put it, "but the quantity of oil should be insufficient to raise the oiled mineral by virtue of the flotation power of the oil alone." After the completion of this part of the process, a suitable gas is generated in or introduced into the mixture, and, as examples, air, carbonic acid and sulphuretted hydrogen, or the like, are mentioned. As suitable substances for the generation of gases bicarbonates or carbonates either soluble or insoluble in water (preferably the latter), or easily decomposable sulphides and the like, may be used with acid solution, and in such cases the addition of the acid may be made, if desired, after the addition of the gas-producing agent. Gases may be produced by electrolytic methods, or by means of various other known reactions.

A second way of carrying this invention into effect is to spray the oil with air or other gases into the pulp or to charge a current of air or other gases with a vapor of a volatile oil and to introduce such gases or sprays, preferably at the bottom of the vessel containing the pulp, by means of a pipe provided with perforations or by
544 other suitable contrivances. The inventors state that the oiled minerals have the power of attaching to themselves, with a greater comparative strength than the gangue particles, the gas bubbles, and are carried by them to the surface. The inventors then call attention to the fact that, when (485—408) an oil spray

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is used, the temperature of the pulp should be so varied as to secure the best results with sprays of oils of varying viscosity. Furthermore, instead of introducing the oil spray in an air supply system, a suitable device of atomizing jets operated by air or by steam and air may be introduced directly into the pulp. The gases used may be other than air, such as carbonic acid, steam or mixtures of these.

The third mode of carrying out the invention is to spray the oiled ore pulp through air on the surface of water. The gangue particles sink at once, whilst the metalliferous particles float, according to the phenomenon of skin flotation.

There are three sheets of drawings attached to the patent, which are highly instructive. The first apparatus consists of a tank containing the pulp, which flows through a pipe coming out from the bottom into a lengthy vessel less deep at the end and where the pulp enters than at its other end. This vessel is provided along the bottom with a perforated pipe in the shape of a helix, which is so arranged that it can be rotated. Air can be introduced through this pipe at the shallow end of the vessel and an arrangement is
545 provided by which the air will carry oil along with it. At the deep end of the vessel a launder is provided on the top and an outlet at the bottom. The working of this apparatus is so obvious that it scarcely requires an explanation. The pulp is fed into the vessel which contains water at the place where indicated in the drawing, the air and oil supply is turned on, and the helix, that is, the perforated pipe, is rotated. By this operation, the coating of the minerals with oil is performed, air is supplied to lift the minerals to the surface, and, after they have arrived at (486—409) the opposite side of the vessel, they overflow into the launder, whilst the sand is removed through the outlet at the bottom. The result of this process is, according to my experimental observations, skin flotation.

The apparatus illustrated by the sketch on sheet 2 consists of a pulp mixer with a pipe leading from the bottom serving as an outlet for the pulp. The pipe is bent rectangularly and contains another pipe inserted, which is intended for admission of air. In front of it is a system of spitzkastens, each of which has at the bottom an outlet and the last one on the top a launder to collect the outflowing concentrates. The pulp is mixed with oil and allowed to run out. It is sprayed by the air or other gas on to the spitzkasten where the gangue will sink, whilst the minerals will float by skin flotation. They are collected by overflow at the end of the system.

The sketch on sheet 3 shows a tank with an outlet which is connected with a cylindrical collar fixed around a vertical spindle,
546 which can be rotated by a driving pulley. Fixed to the bottom part of the spindle is a round disc, which is surrounded by a series of spitzkasten, increasing in depth towards the outside. Each of the spitzkasten is provided with an outlet at the bottom and the most outward spitzkasten with a launder to receive the overflow. The pulp is fed into the cylindrical collar and from there falls on to the disc which is being rotated. The effect of the rotation is to spread the minerals into a fine layer and propel them by centrifugal force into the spitzkasten. The gangue falls, and

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the minerals float by skin flotation. The concentrates are collected in the launder by overflow.

It is impossible to produce, according to the process which is disclosed in this specification, the agitation froth (487—410) of the patent in suit. I have made a number of experiments with the apparatus meant to represent Figure 1 of this patent and offered in evidence by the defendant and marked "Defendant's Exhibit Apparatus of Patent No. 793,808." In this apparatus the overflow, marked B^4 in the drawings, which forms an essential and characteristic part of the apparatus, has been omitted.

Experiment I was carried out to find out whether the agitation froth of the patent in suit could be produced with quantities of oil suitable for the process of the patent in suit. A quantity of Broken Hill tailings of about 4 to 5 lbs. was fed in by hand into the vessel containing the helix, as in the model no provision was made
547 for feeding the ore in in any other way. The oil used was oleic acid and it was sprayed in by air at a pressure of 3¾ lbs. in such manner that one drop came about every two seconds. About 6 cc. were used altogether. The acid which was used was sulphuric acid and it was present in such quantities that at the end of the operation the liquid showed distinct acid reaction. As soon as the feeding in began, the helix was rotated with a speed of 240 revolutions per minute and the rotating of the helix was continued to the end of the experiment, which lasted about five minutes. No froth whatever had formed. A skin of about six inches in length could be observed at the end of the vessel where the overflow ought to have been.

Experiment II. The previous experiment was repeated with larger quantities of ore and with quantities of oil which were sprayed in by air corresponding to two lbs. to the ton. The vessel was filled with water heated to 55° Centigrade. Sulphuric acid in proportions of 22 lbs. to the ton of ore was added to it, and the solution agitated (488—411) at a speed of 240 revolutions per minute. The ore, of which 20 lbs. were used, was fed in by hand at the end near the spray. The spraying of the oil was commenced as soon as the feeding in of the ore had been started. The operation of feeding the 20 lbs. of ore in required about ten minutes, but the agitation was continued for a further four minutes, and then stopped. A film appeared on the surface containing only traces of minerals
548 (less than 50 grams) but no froth. Air was again blown in and the helix rotated for two minutes at a greatly increased speed, namely, 700 revolutions per minute. On being then stopped, again a thin film appeared containing very little mineral, about 50 grams at the most.

Experiment III was made in a different way. 20 lbs. of Broken Hill tailings were made into a pulp in a cone mixer and sulphuric acid in the proportion of 25 lbs. per ton and oleic acid in the proportion of 2 lbs. per ton of ore were added. The temperature of the water was 55° Centigrade. It was then briskly agitated for two minutes in the cone mixer and produced, after settling, a heavy, very excellent froth. The mixture was re-agitated and emptied

during the process of agitation into another vessel, wherein the froth re-formed again very quickly. This proved that re-agitation in a vessel provided with a suitable agitator will always re-form the froth. It was then emptied into another vessel and carried to the apparatus offered in evidence by defendant and representing the apparatus of Figure 1 of patent No. 793,808. Air was then blown in and the helix rotated at a speed of 240 revolutions per minute for five minutes. On stopping the rotation and the air blast, there was a thin skin flotation, but no froth. (489—412)

Experiment IV was carried out with proportions of oleic acid which fall within the Cattermole range. 20 lbs. of ore were mixed with 60 lbs. of water and 4 oz. of oleic acid (1.25% on the ore and about 4% on the mineral) were mixed in a cone mixer for five minutes. After agitation, a partial layer had formed on the top containing very little mineral. Imperfect granules, which owing to slime and not quite sufficient oil, were not as compact as the usual Cattermole granules, were at the bottom. The mixture was conveyed into the helix apparatus described in the previous experiment and the helix was rotated with a speed of 240 revolutions per minute, whilst at the same time air was blown in. The result was an aggregation of pasty particles on the surface, which floated as skin flotation.

From these experiments I conclude, which, however, was quite obvious to me from the study of the plant used for them, that it is impossible to produce the agitation froth of the patent in suit by the apparatus of Fig. 1 of 793,808, and that, however the experiments are carried out, no such froth can be produced in it. The construction of the apparatus is such that the agitation froth, if it were produced therein, would be of no benefit, because there would be no separation from the gangue, and both gangue and mineral would be emptied out together into the launder. The apparatus is clearly intended for a continuous process of the separation of minerals from gangue, in which the minerals are carried in the agitation vessel during the rotation process to the top and the gangue remains at the bottom and is removed from the outlet at the end of the vessel. Moreover, the helix form of the agitator through which air bubbles are blown out at a considerable pressure cannot produce a form of agitation capable of intermingling (490—413) air and pulp in such a way as to lead to an agitation froth, even on the supposition that all other conditions, and proper proportions, were fulfilled. By this form of apparatus air can be blown out, but it cannot be sucked in and form an intimate mixture with the pulp. And what is more, not even the pulp can be properly mixed with the coil of the kind as shown in Figure 1 of patent No. 793,808.

I have read the remarks made by Dr. Byrnes with reference to this patent. The first two pages are devoted to the quoting of a part of the specification. He then discusses specifically the apparatus shown in the three figures. Of the apparatus marked Figure 1, he says that this apparatus "is well adapted to preferentially coat the metalliferous constituents of the ore with a minute film of oil insuf-

ficient of itself to raise the mineral, and also to attach to the oiled mineral particles films or bubbles of air to float them as a froth."

I absolutely disagree with this statement and am convinced from my experiments, that this apparatus is only suitable to produce the phenomenon of skin flotation. The air which is blown through the helix, it is true, attaches itself to the oiled aggregates and carries them to the surface, but the very motion of the helix destroys the air bubbles and the particles which remain on the surface are floated as skin flotation. There may be some of these bubbles left,
551 but to say that this form of apparatus is well adapted for the production of a froth, I absolutely deny.

As to the agitation froth of the patent in suit, that is an utter impossibility.

An agitation froth such as the froth of the patent in suit does not separate whilst agitation is proceeding, the (491—414) gangue at the bottom and the mineral at the top. If he calls the lifting to the top of one or several particles of minerals by a gas bubble, a froth, then I say this is not a froth. Or if he calls the bubbles of air which are propelled from the helix and come through the surface of the water with considerable force, a froth, I again disagree with the term, although there would be no difference of fact.

I further quote from Dr. Byrnes' testimony:

"The coiled perforated pipe will also act as an efficient agitator to entangle and intermingle a considerable amount of atmospheric air with the pulp, assisting the aeration."

This passage is obscure and it does not state whether Dr. Byrnes means that this form of agitation is an agitation which will draw in air from the atmosphere, or whether he means that this form of agitation and the air introduced through the pipe is an especially good mode to intermingle a considerable amount of atmospheric air with the pulp. I disagree with both propositions. As to the first, I say, it is practically the worst apparatus conceivable for
552 drawing in air from the atmosphere, and as to the second, I say, that it is a very bad agitator for producing an intimate mixture of pulp and air, but it is an excellent apparatus for the purpose for which it was used by the patentees, namely, for slowly turning the oiled pulp and giving the air bubbles time to perform their duty, namely, lifting the oiled aggregates of minerals to the surface. A quick agitation is fatal to it.

The use of the apparatus illustrated by Figure 1 of No. 793,808, is intended by the patentees only for spraying oil by means of air into the pulp. That is obvious both from the sketch and from the text, page 2 lines 31-34. My efforts to use it for this purpose were (492—415) futile, and I could not produce any results therewith. I did not succeed in oiling satisfactorily the pulp by this apparatus and I do not believe that it can be done. My failure to get satisfactory results by using the apparatus of Figure 1 induced me to change the mode of operation as described in Experiments III and IV. I am aware that this description is not contained in the document, but the method which I adopted has been also used, but with larger quantities of oil, by the patentees as shown by the testimony.

The quantities of oil to be used in the different processes of this patent are within a very wide range, but the fundamental condition is that the solid particles shall be "moistened" by the oil (Spec., page 1, line 19). That is the lower limit. The upper limit
553 is that the patentees do not desire buoyancy flotation or, as they express it, "in quantity insufficient to raise the oiled mineral by virtue of the flotation power of the oil alone" (Spec., page 1, lines 25-27). This means that the quantity of oil must be less than is required to make the mixture of oil and minerals of lighter specific gravity than water. Of course, the quantity of oil necessary for such purpose is not a constant; it depends on the quantity of the minerals present and their character and specific gravity, but, roughly speaking, it always will require for average ore oil in quantity about three times the weight of ore, that is, about 6,000 lbs. of oil to the short ton of ore. I should say that the quantities intended to be used by the patentees were somewhere between Cattermole and some indefinite limit upwards. I have made some experiments with quantities of oil as disclosed by the patent in suit. It must not be understood that I made these experiments as experiments relating to this patent No. 793,808. There (493—416) is no suggestion in 793,808 of such quantities to be used. The contrary is the fact and quantities as described in the patent in suit were absolutely unknown and undreamt of at the date, October 5, 1903, when the application for 793,808 was filed. The reasons why I tried to make use of the apparatus of Figure 1 of No. 793,808 with quantities of oil as described in the patent in suit were the statements in Dr. Byrnes' evidence, which so utterly surprised me and
554 were so much in contrast with my own experiments that I tested the apparatus not only as described in No. 793,808, but also with the quantities described in the patent in suit. I was simply trying to find out whether the apparatus of Figure 1 of 793,808 could, by introducing the later invention, be made to produce the results which Dr. Byrnes has described. But, as recorded in my experiments, I failed absolutely. I could only succeed when I mixed the pulp in a cone mixer with oil in quantities large enough to moisten the mineral and then submitted the mixture thus obtained in the apparatus of Figure 1 of 793,808 to air, which was introduced through the perforations of the helix, whilst it was being turned.

As to the apparatus shown in Figures 2 and 3 of 793,808, it is enough to say that these apparatus will not produce a froth but skin flotation, and that they are only suitable for such purpose.

Schwarz patent No. 807,501, issued December 19, 1905, describes a process for converting oxides and carbonates of metal into sulphides, and the invention is based on the fact that it had been observed that sulphides have a greater affinity for hydrocarbons as adhesive agents than oxides or carbonates. As a matter of fact, the patentee (494—417) states that the concentration of minerals contained in ores by means of hydrocarbons has been largely confined to sulphide ores. The oxide or carbonate of a metal contained

in the ore is treated either hot or cold with a soluble sulphide
555 in a suitable vessel provided with an agitator. The second part of the patent deals with the concentration of the ore after the mineral has been converted into a sulphide. This process is practically identical with the process contained in 807,503, which latter patent deals exclusively with the treatment of ores for the concentration of minerals by an oil process, and I will consider this second part of 807,501, when dealing with the invention contained in 807,503.

Schwarz patent No. 807,503, issued December 19, 1905, relates to a process for the concentration of minerals in ores by means of a selective material consisting of a compound or mixture of either mineral, vegetable or animal oil with a fatty matter which is solid at ordinary temperatures, such as paraffin, stearine or palmitine. The inventor states in his introduction his view of the state of the art. He says that the separation of the values in ores has been effected by mixing the pulverized ores with a product resulting from the distillation of petroleum, the ore having been previously mixed with sufficient water to form a freely flowing pulp. The process previously used consisted therefore,

(*a*) in the making of a pulp;

(*b*) in the treatment of such pulp with the product resulting from the distillation of petroleum.

In the invention described by the patentee the process consists of the following steps:

(*a*) Mixing of the ore with the selective agent consisting of a mixture of an oil with a solid fat or fatty (495—418) body;
556 such mixture being solid at normal temperatures; and the mixing has to be performed at such temperatures that the oil is liquid;

(*b*) After complete incorporation of the selective material with the ore, water is injected into the mass and the agitation continued until the water is distributed through the mass;

(*c*) The action of the selective material is facilitated and better results secured by the injection of gaseous fluid such as air, steam or gas, into the mass. These three steps are the essential part of Schwarz's invention, and he describes an apparatus in which it is to be carried out.

The ore is mixed with sufficient of the selective material to make a thick, pasty mass in a vessel, steam jacketed or otherwise suitably heated. As selective material, a preference is given by the inventor to crude petroleum or any of its products, with admixture of 9 to 10% of paraffin. After complete incorporation of the selective material with the ore, water is injected until it is distributed throughout the mass, which is accomplished by agitation. The mass is then allowed to subside, when the selective material with entrapped metallic constituents will rise to the top and may be removed in any suitable manner, for instance, by floating over the top of the vessel. This description can only refer to an oil buoyancy flotation. That this view is right is confirmed by the next sentence (page 1, line 70):

557 "The values may be separated from the selective material in any suitable or well known manner—as, for example, by a centrifugal drum or filter-press."

The oil is present in such quantities in the concentrates that its recovery, either by filtration through a (496—419) filter-press or by means of centrifugal apparatus, as described as a matter of course. He continues to say that the separation above described is assisted by the injecting of air, steam or gas, such as carbon dioxide, into the mass. By the term "mass" he clearly understands the mixture of ore and oil, and it is another indication of the very large quantities of oil which must be present. I must express my surprise at this point about an experiment described by Dr. Byrnes. He mixed 500 grams of ore with 20 cc. of cottonseed oil, the mixture having the consistency of molding sand. I cannot conceive how Dr. Byrnes imagined that that was Schwarz's invention and how he thought he could blow air through a mixture of the consistency of molding sand and what the effect would be if it could be done. I shall have to criticise his experiment later on and will therefore go back to Schwarz's invention.

The effect of the injection of air, etc., into the mass is completely to subdivide it and break it up and it results in the selective material taking up an appreciable quantity of air or gas which, giving a certain sponginess, increases its floating power. The intention of the inventor is quite clear. Air bubbles are retained in the
558 viscous oil and are as such instrumental in reducing the specific gravity of the mixture of oil and mineral. After the addition of water, which is carried out by suitably arranged pipes, the addition of air is continued, in order to assist in the distribution of the water throughout the mass and to effect the thorough separation and washing out of the tailings.

The separation of the concentrates can be effected, the inventor states, in two ways. If cold water has been employed in the process, then the selective agent will be (497—420) solidified and inclose the minerals and will rise to the top and will be conducted from there by a trough to a remelting and storage vessel. If heated or boiling water has been employed, the selective agent will be maintained in its liquid condition and will be run with the metallic constituents entrapped therein into a storage vessel. Whether the minerals are collected entrapped in the solid selective material, or in the heated fluid selective material, the oil is separated from them in the first case after remelting of the oil by the process of filtration, which again indicates the large quantity of oil used in this process.

An apparatus is described to carry the process into effect. The powdered ore flows through a hopper into a vessel, preferably steam jacketed, and provided with an agitator. In this vessel, the ore is mixed intimately with the oil and then flows through a trough into another vessel. That the mixture can be conveyed in such a
559 simple manner from one vessel to another is again a proof of the large quantity of oil which must be present in the mixture. The second vessel is again provided with an agitator and serves for the purpose of the retreatment of the oil mixture with

water, which latter may be acidulated. This vessel is provided with pipes for the introduction of air, steam or gas, and with a pipe for the discharge of the tailings. After the separation, the oil with the minerals is run into a storage vessel in which, if solid, the oil has to be remelted, then it is taken from there to a centrifugal drum for the separation of the values from the oil.

A careful consideration of this invention makes it absolutely clear that it is an oil buoyancy flotation (498—421) process, the buoyancy of the oil being increased by introducing into it some air which will remain mixed up with it in consequence of the viscosity of the oily mass. The novelty in the invention is the selection of a specific mixture made from two component oily substances, which results in a solid, and the use of such solid in such way that the resulting mixture of oil plus mineral can be collected and separated either as a liquid containing the mineral or as a solid containing the mineral. Another feature of the invention is the increase of the buoyancy of the oil, that is, of the carrying power of the oil, by aerating the oil and inclosing air bubbles within the oil.

I have said in the discussion of the Schwarz patent previously described that the process of the former patent and of this pat-
560 ent, so far as relates to the separation of the minerals from the ore, are identical, and I repeat this. The other patent considers as the essential feature of the invention the conversion of an ore, such as oxides, carbonates and chlorides, into sulphides, to render them suitable for the treatment by hydrocarbon, which means an oily material. It was well known that generally such minerals as sulphides were substances suitable for treatment with hydrocarbons or oils, and the idea of the inventor is to make other minerals suitable for the same kind of process by converting them into sulphides. I have not carried out such a conversion and I cannot speak as to its result from personal experience. But the possibility of concentrating sulphides by an oil process depends solely on certain physical properties. It is not a chemical process. Sulphide ores as occurring in nature have got these essential properties, but I have grave (499—422) doubts whether a sulphide as proposed to be made by the process described in Schwarz's first patent will be suitable for an oil treatment to make concentrates of the minerals. Sulphides produced by the action of solutions of sulphides, such as sodium sulphide, have usually quite different properties from the sulphides in nature. The latter are crystalline products of metallic lustre, looking just like metals. The sulphides made in the laboratory or in works by precipitation or conversion, are amorphous products, which cannot be mistaken for metals and which have none of those characteristics which I enumerated
561 as belonging to the sulphides found in nature.

I have read the conclusions drawn by Dr. Byrnes from this specification and the facts which he finds revealed in it. I disagree with most of his statements and they strike me as an essay not dealing with the exposition of a perfectly plain and straightforward invention, but how to disguise these plain facts and make them appear as something quite different, of which there is not a

grain of substance contained in the patent. As to paragraph (3), I say that it is ambiguous and does not express the true meaning of that part of the patent which refers to it. It reads:

"The use of a sufficient quantity of the oil or oily mixture to effect the desired separation, that is, the oiling and floating of the metalliferous constitutents."

The patentee directs the use of a quantity of oil sufficient to form with the mineral a thick, pasty mass, which, as the oil is solid, may mean a large quantity, sufficient that the oil can be recovered by filtration, sufficient that it can carry the mineral and still float, sufficient that it can enclose, when solid, the mineral and still float. These are the directions I find in the (500—423) patent and they all indicate a considerable quantity of oil to be used. The statement of Dr. Byrnes as it stands would include the quantities of the agitation froth process. I scarcely need add that even the wildest imagination cannot discover any other process in this patent but
the oil buoyancy flotation, assisted by the enclosure of some
562 air bubbles in the oil.

I disagree with the facts and the conclusions drawn in paragraph (5). The mechanical agitation referred to in the patent can only be a comparatively slow one, as it is very difficult to agitate quantities and proportions as they would occur in the mixing of oil and minerals, even if the quantities of oil are such as are required for oil flotation, and there is no difference mentioned in the specification between the mixing of the oil with the minerals and with the agitation for distributing the water through the mass of ore and oil. It simply says, the agitation is continued. I disagree with the statements contained in paragraph (6). There is not a word mentioned of the formation of a froth. What the patent says is that the selective material, that is, the oil, takes up an appreciable quantity of gas, which gives it a certain amount of sponginess, which increases its floating power, that is, the floating power of the oil, by the enclosing of bubbles of air within the oil.

As to paragraph (8), after "the centrifugal filter" the addition ought to be made: for the separation of the concentrates and the recovery of the oil.

The experiments described by Dr. Byrnes as carrying out the process of these Schwarz patents have no similarity whatever to the process described by Schwarz. Dr. Byrnes (501—424) used 500 grams of defendant's ore and mixed it with 20 cc. or, in weight, about 18 grams of cotton-seed oil. I should like to know how this
mixing was effected. I cannot conceive, unless there was
563 some special device, how he could mix 500 grams, that is,
125 cc. of a dry powder, with 20 cc. of liquid. The result had the consistency of molding sand, i. e., of an almost dry powder. The patent directs you that you are to have a thick, pasty mass. The mixing of a pulp with 3.6% of oil is an easy matter. There you have a large quantity of water with it, and by brisk agitation you break the oil into small particles, which are then capable in another medium, namely, water, to perform the function of coating the mineral. But to mix 500 grams of ore, which if it was a solid

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block would fill a space of 125 cc. but which, being in very fine division, prevents an enormous surface, with 18 grams or 20 cc. of oil, seems to me a very difficult operation. The function of the oils, according to the description of this process, is to carry the minerals. Taking the percentage of minerals to the ore to be 30%, the 20 grams of oil, after solidification, have embedded in it 150 grams of minerals. I need not comment on this. These 20 grams are then remelted and the oil separated by a centrifugal drum or by a filter press. How the process is carried out of separation by filtration of 20 grams of oil from 150 grams of mineral, I do not know. I should like to add, that the patent provided for an apparatus for mixing the ore with oil. It is an ordinary agitator. I feel inclined to say from practical experience of such apparatus that the agitator would refuse to work with quantities as used by Dr. Byrnes. Dr. Byrnes then mixed this oiled mass with 1700
564 cc. of water acidulated with 1 cc. of sulphuric acid, the water having a (502—425) temperature of 76° Fahrenheit, and agitated it for the purpose of aeration in the apparatus which he calls the Hyde slide machine. These are not the directions of the patent. The patentee directs you to aerate the mixture of ore and oil and not the mixture of air, oil and water, and to do this by introducing air through a set of pipes into the mixture of ore and oil. To pass air through pipes into a mixture of ore and oil having the consistency of molding sand, would soon put a stop to the introduction of air. If the pressure were strong enough, the air would force an opening through the mixture and pass out without any benefit to the mixture; or, if the pressure is not strong enough the mixture would stop up the pipe. That my contention is right is shown by the following passage (Spec., 807,503, p. 1, lines 85-100):

"This may be done by suitably arranged pipes leading into the bottom or sides of the vessel, the effect of such use of air, steam or gas being to break up and subdivide the mass in a complete and thorough manner. Furthermore, it results in the selective material taking up an appreciable quantity of air or gas, giving a certain amount of sponginess, which increases its floating power. After the admission of water, which may be done by suitably arranged pipes, *the admission of air, steam, or gas may be continued* to assist in distributing the water throughout the mass and to
565 effect a thorough separation and washing out of the tailings" (Italics mine).

Dr. Byrnes agitated for 30 seconds, at a speed of 1600 revolutions per minute, and says that a heavy froth was produced, which he removed. I have never seen with such quantities of oil the production of a heavy froth. He removed the first froth and repeats the operation of agitation and production of froth six times and these froths were combined and assayed. I have carefully gone through the specification to find any passage which might warrant him to carry out the Schwarz patent and the treatment of the tailings remaining after the first separation in the (503—426) way he did. The only passage that I can find is contained on page 1, line 73 et seq., and reads:

"The tailings, being unaffected by the selective material, will remain in the water and settle to the bottom of the vessel, from which they may be drawn off and, if necessary, subjected to further treatment for the recovery of any values they may contain."

What the patentee directs you to do is to withdraw the tailings and subject them, if necessary, to further treatment for the recovery of any values which they may contain. In other words, as I understand this passage, the tailings are either added to the next lot to be treated or are treated by themselves by the process as described in the specification. This would mean that they are to be
566 again mixed with the quantities of oil required by Schwarz. Dr. Byrnes retreats them without adding any oil and thus gets rid of a great deal of his oil. Whatever results he obtained, he was not carrying out the Schwarz specification.

This experiment described by Dr. Byrnes as being a performance of the process contained in Schwarz's specifications, 807,501 and 807,503, does not carry out the inventions described in these documents and is utterly different from the process described in these patents.

Schwarz's process is a process for separating minerals from ores by buoyancy oil flotation, assisted, as the inventor believes, by the presence of air bubbles in the oily mass. It resembles, in many respects, the older known buoyancy flotation process, but the patentee uses an oil solid at normal temperature and in that it differs from the older one. He believes he will be able to separate the concentrates either entrapped in the liquid when working at a higher temperature, or inclosed in a solid (504—427) oil when working at normal temperatures.

There is no resemblance whatever in the process of this patent with the process of the patent in suit, and the phenomena serving for effecting the concentration of minerals in the two inventions are absolutely different. The principle of the Schwarz process is well known and has been previously used in processes of entrapping the mineral in such quantities of oil that the specific gravity of the combined mixture is less than water. It is differentiated from the earlier processes of this kind by the introduction of some
567 minor variations and by the introduction of air, steam or gas to increase the carrying power of the oil. The agitation froth phenomenon is absolutely new and nothing like it had been known, or used, before its discovery was revealed by the patent in suit.

The Kirby patents No. 805,959, issued January 16, 1906, and No. 838,626, issued December 18, 1906, involve the separation of minerals, partly by buoyancy flotation, partly by lifting the aggregates of minerals in oil by air bubbles. The quantities of oil which the inventor claims obtain excellent results are from 500 to 1500 lbs. of oil per short ton of ore. The oil is recovered by filtration and distillation.

(The witness fully described details of the process and apparatus disclosed in this patent.)

The apparatus is worked in the following manner: The agitation in the first tank must be thorough. It serves to oil the pulp. The agitation in the second or separating tank must be gentle to accomplish the purpose for which it is used, namely, allowing the air bubbles to attach themselves to oiled aggregates of minerals. It is specified that it has to be gentle. (505—428)

Only a few points are of importance according to the inventor:

(1) The introduction of air and the necessity of gentle agitation, that is, the gentle turning over of the mass in the separating tank into which the air is introduced.

(2) The additional novelty of saving the hydrocarbon
568 liquid by distillation.

(3) The possibility of the use of a thin hydrocarbon for the purpose of the recovery of the mineral.

The experience which I have gained from experiments makes me doubt whether the assertion made under (3) is a fact. In my view, no thin oils can be used with advantage, and the patentee himself describes that the minerals collect on the bottom of the layer of the thin oil which is near the water surface. That involves that the minerals continuously break through by sheer force of their weight and return to the bottom of the water, which renders of little use all the processes in which gas is generated or introduced through pipes for the purpose of lifting oily aggregates.

The fact stated under (1) is of importance and correct. The attempts to attach air bubbles to aggregate of oiled minerals can only succeed by gentle turning over of the mixture of sand and oiled particles. Thorough agitation would make it absolutely impossible.

The process of separation of minerals revealed in this patent is a process of buoyancy oil flotation assisted by the inclusion in the oil of air bubbles. Dr. Byrnes states what in his view are the points shown in the two Kirby patents. I think there ought to be added to (2), "excellent results" being obtained by using 500 to 1500 lbs. of oil to 2000 lbs. of ore. (506—429)

As to (5), the tank A is described as being preferably
569 cylindrical and in this it differs, according to the evidence of defendant's plant, from defendant's tanks, which are square. The effect of agitating in a round tank is different from the effect of agitating in a square tank, even at the same speed. It is much less thorough. But I object to the comparison of a process of incorporating 500 to 1500 lbs. of oil with a ton of ore, with a process for incorporating 2 lbs. of oil with a ton of ore. These two processes do not allow of comparison. What would be thorough agitation in the first case might be highly inefficient in the second case. The whole of the paragraph is not clear to me, and I cannot understand the remarks:

"(5) The thorough mechanical agitation of the ore-pulp acidulated, and the oil, by a rapidly rotating shaft having radial agitating blades, which type of agitator, employed by the defendant in this suit, is found to be a most efficient one for intermingling atmospheric air with the mass and thoroughly aerating the oiled mineral to produce a floating froth of concentrates."

If Dr. Byrnes means only that the apparatus called the mixing-tank A of Kirby's patent, which is by preference cylindrical, is as efficient as the square box at the same speed, I have already disagreed with this proposition. But if he further wants to imply that Kirby produced a froth in his process, then I say that is not so, and it is clearly described in the document that it is not so (Spec. No. 809,959, p. 3, lines 55-58):

"The floating concentrates are carried mainly at the lower
570 surface of the hydrocarbon layer, where it is in contact with the water."

And this passage also contradicts the allegation expressed in (6) that the concentrates form a froth. Dr. Byrnes calls any liquid in which some air bubbles are inclosed a froth. My definition, and I believe it is a (507—430) true one, of a froth is, a collection of bubbles surrounded by liquid films appearing on the surface of a liquid. Dr. Byrnes describes an experiment which again proves that he cannot put himself into the condition of the knowledge which existed at the time of Kirby's application for Letters Patent. He improves the process by using all the knowledge which he has got to-day. If a patent or publication is meant to serve as an anticipation to a later patent, it ought to reveal the invention, and in carrying out the process for that purpose, it ought to be carried out as described. Kirby's patent directs you to agitate thoroughly to effect thorough oiling of the minerals, then to agitate gently and to introduce a current of air through pipes into the bottom of the agitating vessel to carry those aggregates of oiled mineral which had been left at the bottom to the surface of the water in order to unite them with the layer of hydrocarbon which had collected there after the first agitation was stopped. Dr. Byrnes uses a "Hyde slide machine" for his experiment and says, by using this machine "I was able to oil and aerate without any injection of streams of air to
float the particles entangled in the tailings." The directions
571 of the patent are: Oil the particles thoroughly and agitate them in an apparatus different from the slide machine and allow the mixture to settle, when a layer of hydrocarbon will appear at the surface of the water and a number of aggregates of oiled particles will be with the sands at the bottom of the water; then agitate gently, that is, turn the sand with oiled particles slowly over (Spec., p. 2, lines 61-63 of 809,959):

"The mass which tends to settle is slowly lifted and turned over to liberate the coated particles and the globules, and at the same time a gas, preferably air, is blown into the mass preferably near the bottom thereof." (508—431)

I say that Dr. Byrnes did not carry out Kirby's invention at all in this experiment and there is no similarity between Dr. Byrnes' process and the process and apparatus revealed in the two Kirby patents. Dr. Byrnes says, he also roughly imitated the operation of blowing air carried out by Kirby by the use of a single tube pushed downward into the tailings at the bottom and moved about therein, but he does not say what benefit he got from it. Apparently none, because he removed the first froth which, according to my

experience, must have been a layer of hydrocarbon liquid with some air bubbles inclosed, and then continued agitation and aeration (he does not say how often). The tailings were left comparatively light in color; that is, they consisted, according to his statement, largely of gangue.

I have performed an experiment with the Kirby process, using the slide machine which had been used by Dr. Byrnes: 500
572 grams of defendant's ore, which had been crushed in my presence to 80 mesh and which contained 18.1% of zinc, 1600 cc. of water, 1 cc. of concentrated sulphuric acid, were made in a good pulp, then 125 parts of a solution containing in 105 parts 100 parts of kerosene and 5% of Trinidad asphalt, were added, and the mixture, having a temperature of 35° Centigrade, was thoroughly agitated for five minutes. After stopping the agitation a layer of oil settled on the surface of the water, which layer of oil inclosed minerals, some bubbles of air and some water. The mass of gangue and pasty minerals which was at the bottom of the water was then gently agitated, and gas injected into it through a pipe, which was coiled at the bottom and perforated in the coiled part. The result of this operation was that the layer of oil and mineral which was on the surface of the water was disturbed in such a manner that most of the oiled (509—432) minerals sank to the bottom of the apparatus, and only a very small part of it was left on the surface of the water mixed with very few air bubbles. As this operation proved so unsuccessful, another 250 grams of kerosene-asphalt solution was added in a stream to the mixture which was being gently agitated at the time. The result was that oil was both on the surface of the water and at the bottom. Therefore, the thorough agitation was repeated for one minute and more oil came to the surface of the water, but on blowing air in whilst the mass was being
573 gently agitated at the bottom, part of the oil again sank. The layer of oil on the surface was taken off and the gentle agitation of the residue was so often repeated as oil would come to the surface, and each time the oil which had risen was collected. The result of this experiment was the recovery of 39% of the zinc contained in the ore.

The Kirby patents and the process revealed therein have nothing in common with the patent in suit and the process revealed therein. The Kirby patents and process rely on the separation of the minerals from ores by buoyancy flotation of the oil and mineral, assisted by the enclosure within the oil of air bubbles. It is apparent from the documents that it is not intended as something different, and the physical phenomenon involved is well known and had been used for that purpose before. The process of the patent in suit depends on a new and entirely different phenomenon, which is neither revealed in Kirby's specifications nor in any of the other documents which form part of defendant's case as to anticipation.

Relative to agitation, the patentee says that the separating tank can be used for both the mixing of the (510—433) oil with the pulp and for the separation of the oiled particles from the gangue. I quote as follows:

"It is merely necessary to rotate the agitating mechanism rapidly while mixing and to rotate it slowly while the separation is being made" (Spec., 809,959, p. 3, lines 121-124).

574 It is self-evident that during the oiling of the pulp the air supply is cut off.

A certified copy of the Italian patent to Alcide Froment, No. 63,723, the specification of which bears the date May 20, 1902, is now offered in evidence and marked "Complainants' Exhibit Froment Italian Patent."

I have read and understood the Froment Italian patent 63,723 of May 20, 1902. This patent is in the French language, and I have made a translation thereof into the English language. I have been familiar with the French language for very many years.

The translation produced by the witness is offered in evidence as "Complainants' Exhibit Translation of Froment Italian Patent."

It is stipulated that the Froment British patent No. 12,778 of 1902 was sealed August 18, 1903.

The Froment British patent contains a provisional and a complete specification, the former being identical with the latter, except in the fact that the complete specification contains a claim. I will therefore only take the complete specification into consideration.

The invention disclosed in the Italian Froment patent and in the British Froment patent is identically the same in both documents. There are slight differences to which I will call attention when coming to them.

The invention relates to the concentration of metalliferous (511—434) ores and earths, and the patentee states it to be a mod-

575 ification of the known oil process for the concentration of ores, or, as he says, "a modification of what is known as the oil process of ore concentration."

The only process known as the oil process of ore concentration at that time was the Elmore oil buoyancy flotation process. Further, it is in evidence that the Elmore process was tried at the Traversella Mine in Italy, where Mr. Froment was the engineer, as testified to by Mr. Ballantyne. I am sure, therefore, that this statement, which is in the forefront of the specification, can only refer to the Elmore buoyancy oil flotation process.

The inventor then continues and describes four phenomena, which serve as a basis of the process which forms the substance of his invention:

"(1) When natural sulphides reduced to powder are moistened by a fatty substance, they have a tendency to unite in spherules and to float upon the surface of the water." This means that the ore must be mixed with a substantial quantity of oil, as such a tendency only results if ore is mixed with sufficient oil to substantially reduce its specific gravity.

"(2) This tendency is simply retarded by the specific weight and opposed by the gangue which imprisons the moistened sulphides in its pulverulent mass." From this statement it is clear that Froment does not contemplate using the large quantities of oil which were

used in the process well known to him, namely, Elmore's
576 process, because he suggests that the specific weight of the
mixture of minerals and oil is larger than water. But this
is not the only reason which he gives. The mixture of mineral and
oil which he had produced was imprisoned by the (512—435)
gangue and the gangue prevented or opposed the rising of the oil
moistened sulphide. There can be no doubt that both gangue and
the oiled sulphides were at the bottom of the liquid.

"(3) If a gas of any kind is liberated in this mass, the bubbles
of the gas become covered with an envelope of sulphides and they
rise readily to the surface of the liquid where they form a kind of
metallic magma." The inventor found that, when a gas is generated
in this mass, as he says in his Italian patent, the gas envelope will
attach to itself the oiled minerals, rise with them to the surface of
the liquid and form a magma, which is a pasty mass and which
consists of a substantial quantity of oil carrying minerals and having
gas bubbles enclosed in the oil.

"(4) The formation of these metallic spherules is singularly
active if the gas is in a nascent state." It is not quite easy to under-
stand the meaning of the patentee, but I will give my interpretation
of it. In paragraph (1) Froment says that the sulphides have a
tendency to unite in spherules when they are moistened by a fatty
substance. This would mean that with a sufficiency of oil and op-
portunity of coming together, spherules or little globes or blobs of
oil containing sulphides would be formed. These spherules or blobs
would, of course, have no gas in them, but oil.

577 In paragraph (4) Froment says that the "formation of
these metallic spherules is singularly active if the gas is in
a nascent state." I say with reference to this paragraph, it is reason-
able to assume that Froment was describing the formation of minute
gas bubbles and the flowing of the mineral embedded oil about these
minute (513—436) bubbles. The spherules of paragraph (4) differ
in this respect from the spherules of paragraph (1). In the latter
case we have got little spheres of oil containing sulphides. In the
former case we have little spheres of oil containing sulphides, but
each having a small bubble of gas in its center. In one case the
spherule means a solid little sphere of oil; in the other case, the
spherule is a hollow little sphere of oil. The mineral particles
entrapped in the oil would, of course, be carried by the gas and
when these bubbles, coated with oil and mineral, rise by their buoy-
ancy, they will go to the upper surface and in this upper surface
the liquid oil on the several bubbles would be united in a paste of
oil and minerals having air bubbles in it. To express it in a different
way, the identity of the spherules would be lost. We would have
on the surface, as Froment says, "a magma" of oil separated from
the rest of the liquid, thickened by minerals, and containing gas
bubbles throughout its oily mass which would lighten this magma
and increase its buoyancy. I have found in my experiments that
this oily mass or magma, floating at the top of the liquid, does not
contain spherules or little spheres, but that it is a mass of
578 oil in which the identity of the spherules has been lost.

From these statements contained in the fourth paragraph

of which I have given my interpretation, the process intended to be used is quite clear. Froment mixes a pulp, either containing a carbonate or to which one had been added, by agitation with quantities of oil which are suitable for his purpose, namely, that the oil-moistened minerals are contained at the bottom of the vessel intermingled with the gangue. It is clear to me, quite (514—437) independent from the guidance which I find perfectly definite in the specification, that he used large quantities of oil, very large, if we compare them with the quantities used by the inventors following him, for instance, Cattermole. Froment's process is a modification of the process which is known as the oil process of ore concentration, which, as I have said, was Elmore's process. Froment endeavored to reduce the large quantities of oil which are necessary for Elmore's process, and to effect an economy. If he did make experiments systematically, he would find that his first efforts would result in the production of a layer of oil on the top of the water with minerals therein and of some oil with minerals embedded in the gangue. He would finally arrive at a point where all the oil plus minerals was embedded in the gangue only. He would notice that they contained such a large quantity of oil that there was a tendency in them to flow together and to form spherules or globules, but these
579 globules would not rise because they are too heavy. Then he evolved the idea of trying to lift them (the oiled minerals) by means of a gas and he found that when he generated the gas in the mixture, produced it in statu nascendi or nascent condition, he produced spherules which rose with ease to the top, united there and formed a magma.

After he had mixed his oil and ore, which was resulting in the dissemination of the oiled minerals through the gangue which contained a carbonate, he would add the acid to generate his gas, carbonic acid, and the gas would first form the spherules and these would rise to the surface and form the magma. He would collect the magma, separate the oil from it, as is later described in Froment's patent. This is the process which this fourth paragraph revealed to me. (515—438)

He then describes, not an example of how to carry out ore concentration as a manufacture, if I may use that term, but a test tube test, in which any one could quickly see the result of his discovery. He says:

"Thus for example, if in a test tube there is placed say ten grammes of sulphuretted copper ore with its gangue, a gram of limestone, the whole reduced to powder, and if there is added thereto thirty grammes of water, a few drops of sulphuric acid and a thin layer of ordinary oil, and the mixture then agitated for a brief space, the whole of the copper pyrite will instantly rise to the top of the liquid. The metallic spherules, pressed one against
580 the other, will become grouped in a magma clearly separated from the rest of the liquid. If the limestone is in excess, or readily attackable, the rapidity of the separation is so great that the copper pyrite is forcibly projected outside the vessel. There is therefore a proportion to be sought for a given ore and limestone."

I will call attention at once to the fact that the agitation which is described here as being an agitation for a brief space, is described in the Italian patent as being an agitation for a second.

It is not clear to me from the description given what the experiment means. I tried to perform it by following verbally the instructions, but the result was such as is very frankly stated by the inventor, namely, that the contents of the test tube found another abode on the walls of the laboratory. I cannot understand the sentence finishing the before-quoted paragraph. The proportion between ore and limestone cannot prevent the ejection of the contents of the test tube if there is a sudden generation of gas, and if there is an agitation for a brief space, that is, one second, as definitely stated in the Italian patent, there must always follow the destruction in the way I explained before. The Italian specification precedes the English one by a short time and the English is clearly a translation of the Italian (516—439) document with such slight alterations as a translator who was a British patent agent, would make.
581 There are some other mistakes in the British document which cloud the true meaning of the original to which I shall have to call attention later.

I have stated before that the first experiment produced according to the test tube example, page 2, lines 33-42, was a failure. The whole contents of the test tube were violently scattered through the laboratory. I must add that if precautions are taken, it is possible to perform the experiment and to see the oily magma which appears on the top of the aqueous surface. The magma, which was an oily layer containing minerals and carbonic acid gases, had separated from the rest of the liquid. A superficial observation would perhaps give the impression that it had the appearance of a froth, but it is not a froth. It is only a layer of oil in which minerals and carbonic acid bubbles are embedded. In some respects I had difficulties to understand this example. I gather from the description preceding the example that part of Froment's invention, and it is an important part, relies on the generation of a gas in the nascent state within the mixture of the moistened sulphides and gangue. The addition of the 10% of calcite (one gram) can only be for the purpose of serving as a source for the nascent carbonic acid gas. There can be no other use for it. Yet the patentee says in his example, add "a few drops of sulphuric acid."

Perhaps it would be useful to explain the function of this sulphuric acid. Calcium carbonate is a combination of calcium oxide
582 and carbonic acid. In order to release the carbonic acid from the calcium carbonate, which chemists (517—440) call the calcium salt of carbonic acid, it is necessary to act on it with a stronger acid which expels the carbonic acid and takes its place. Chemistry teaches us that this action is produced by using definite quantities of both calcite and sulphuric acid and that to get all the carbonic acid from one gram of calcite, one gram of concentrated sulphuric acid is to be used. It is clear that the calcite is present only as a source of carbonic acid, yet he uses for the decomposition of one gram only a few drops of sulphuric acid, which must be less

than one gram. The quantity of oil to be used in the test tube experiment is also not well defined. He only defines the least quantity which can be used and does not give us the upper limit. The least quantity is easily determined and I find it to be 12½% of oil in relation to the ore, but he doesn't say, use the thinnest layer of oil which can cover the surface of the water, but a thin layer, which might be substantially larger than the 12½% which I found was the quantity which would form the thinnest layer on the water surface contained in the test tube suitable for this experiment. 80 cc. of water would fill the test tube and its diameter was about .9 of an inch. As I said before, certain points can be gathered from this test tube experiment. On the other hand, no satisfactory details of the process are given and to infer it from the description
583 is rather difficult. The next paragraph states the result. The mechanically conveyed gangue falls down and the sulphides remain in a state of almost complete purity. Then follows a remarkable sentence:

"Such is the principle."

The Italian document did not give me any assistance in explaining what he meant by this. I have understood (518—441) the preceding part in which he laid down, in four paragraphs, the principles on which his invention is based, as stating the principle of his invention.

The next sentence seems to me to emphasize the short duration of the preceding experiment. The English patent says, "agitated for a brief space," which defined by the Italian specification, of which the English document is a translation, means "agitated for a second," and must be advice to generate the carbonic acid as quickly as possible; at least, I cannot draw any other conclusions from it.

The word "thus" beginning the last paragraph on page 2, before example 1, is an unsatisfactory translation of the French. It ought to be "accordingly," as in my translation.

Example 1 is so brief and devoid of information that I did not get any assistance from its study and I feel that I should quote it:

"Example 1.

A cuprous ore containing 12% of copper pyrite, 15% of
584 iron pyrite, 20% of carbonate of iron, 16% of dolomite and calcite and 37% of various gangues have been submitted to my said process. It should be stated that this ore could not be enriched economically by any known means.

Only a few seconds were necessary for completely separating the sulphide of copper from the rest of the gangue in which no single trace of copper could be discovered by analysis."

Is the process referred to in this example the test tube illustration, which he calls his "principle," or what is it? It is not revealed in the description, and the brevity of his description is, in this case, not resulting in concise information. As a matter of fact, the only information conveyed by the description is that only a few (519—442) seconds are necessary for complete separation. If any con-

clusion is to be drawn from this example, it must be that it is a repetition of the first test tube example, as only a few seconds were necessary after the one second agitation to obtain the separation of the sulphide of copper "from the rest of the gangue," which surely should have been, from the rest of the ore.

Example 2 is even shorter than example 1. I will quote it:

Example 2.

An ore having 10% of lead and unmarketable with such a proportion has been treated in the same manner and with the same success."

585 It is certain, from the description of the two examples, that they are not examples of the carrying out of the process, but that they are examples of ores which Froment had shaken with oil, calcite, water and acid, for a second in the test tube. At the end of the example, the patentee states:

"There are several operations which are distinct but which are connected in carrying the process into practice; the formation of the spherules and their separation from the gangue, then separation of the product of the concentration from the oil and recovery of this latter for readmission to the cycle of operations. The products of the concentration *from* cakes."

In my translation of the Italian patent, I corrected this to read as follows:

"There are several distinct but connected operations in the practical working of the process; the formation of the spherules and their separation from the gangue, then separation of the concentrate and the oil and recovery of this latter for re-entrance into the circuit of operations. The products of the concentration form oil cakes."

This addition is again very devoid of information. It does not assist in carrying us farther than the test tube example. It doesn't state facts which would be of (520—443) assistance in carrying this beyond the test tube. One may infer from the words:

586 "the formation of the spherules and their separation from the gangue,"

that the patentee contemplates first the production of oiled minerals heavier than water and buried in the gangue, but he does not say how he produces them; that he contemplates the formation of spherules from these oiled minerals and their separation from the gangue by generating a gas in the mixture of the oiled minerals with the gangue, but he does not describe such an operation and the conclusions can only be arrived at by inference. But one definite fact is clear, namely that he uses substantial quantities of oil, which he recovers, and clearly by one of the old and well-known processes used for such operations, either by squeezing the oil out by means of a filter press or by centrifugal force, etc. That follows clearly from the last sentence:

"The products of the concentration form cakes,"

or, as it is stated more correctly in the Italian document from which apparently the translation was made,

"The products of the concentration form oil cakes."

The latter expression is more correct, as it is impossible by the use of filter presses and similar apparatus to squeeze out all of the oil from a mass of minerals and oil. At the best, from 8 to 10 per cent will be left with the minerals.

The claim which reads—

587 "The herein described process for the concentration of metalliferous ores and earths which consists in mixing the finely powdered ore or earth with water, adding a suitable oil and then liberating a gas in the mixture substantially as described and for the purpose specified"— (521—444) is very obscure. If it is meant to contain the process which is described, it is true, only as a test tube example, then it does not do so. The only construction which I can put on it, if I may offer an opinion on a subject the decision of which rests with the Court, is as follows: Make a pulp, mix a suitable oil with it and liberate a gas in the mixture. I fail to find such a process in the body of the specification. No doubt the principles on which the invention is based, and which are contained in paragraphs 1, 2, 3 and 4 of page 2, might be described by the language of the claim. But the only process which is described is quite outside of it and I fail to find the process in the language of the claim.

The impression which is conveyed to me by Froment's patent may be summarized very shortly. The intention of the inventor was to modify the process of ore concentration known as the oil process of ore concentration. It is clear to me that he wanted to do this by making an economy in the use of oil, which is very large in the only oil concentration process which had been practically tried. The

588 principles which guided him I can also understand, but when we approach what ought to have been the full description of a working process and of the means by which it could be accomplished, they are not disclosed in the document. The whole invention is based on the test tube experiment, of which he says that, if the mixture is not right, or, to put it in his own language, if there is an excess of limestone, the rapidity of the reaction is so great that the valuable material is ejected from the vessel. Only one fact stands out clearly. He must have used substantial quantities of oil for his test tube example, which I have proved by the actual estimation of the smallest (522—445) quantity which would be in accordance with his description, and which is proved as well by the fact that he describes the recovery of it. Having had the practical experience of the Elmore process, he was, of course, conversant with the mode of recovery therein practised, and he would know the limits for which it was practicable. The invention of Froment consists in an idea not yet realized, but which might have contained a germ, from which a process capable of practical working might have been derived, although it is difficult to see how it could have been a practical success.

"Complainants' Exhibit Froment Description," "Complainants' Exhibit Froment Plan," "Complainants' Exhibit Froment Drawing A" and "Complainants' Exhibit Translation of Froment Description and Descriptive Matter in Froment Drawings." I gather from the evidence that the description and the different drawings came
589 into the hands of the complainants about a year and a half after the filing of the British provisional specification, that means, after the application for British letters patent, and it should contain the experience of Froment, or the development of the thoughts of Froment during the interval.

In order to understand the plant which is revealed in the drawings, I will first deal with that part of the written description which is marked "Instructions." Ore to be perfectly disintegrated without being rendered impalpable should be crushed in two operations. The first crushing should be done in a Ball crusher mill or in a Griffin mill or any other mill, in such manner that it should pass through sieve No. 15. The second crushing should be of such kind that the ore will pass through a sieve of about 120, (523—446) and a Huntington mill or a stamp-mill, etc., should be used. The output is much greater by the dry process than by the wet process, but there is also a greater proportion of impalpable particles. The slimes which are too fine to be treated, and which one has not been able to treat hitherto by any method, have to be eliminated by submitting the ore to two or three spitzkasten. It is from there introduced with a little water into the mixing apparatus for which 200 to 300 kilos constitute a charge. About 1% of carbonate of lime, the maximum in difficult cases being 2%, and about 1 to 1½ per cent of mineral engine oil are added, and the mixture is agitated for about
590 ten minutes, the chief point being that all the sulphide particles should be well oiled. The instructions continue that if the ore contains more than 5% of metallic matter, such as copper or lead, it will be necessary to add a little more oil. Generally, however, one may assume that the following quantities may suffice:

"1% of oil for ore containing up to 5% of metals; 1½% of oil for ore containing up to 10% of metals; 2% of oil for ore containing up to 15% of metals."

The instructions then contain some observations about concentration of ores, and which ores were usually concentrated in the Latin countries. Copper ores, with 15% of copper, are considered very rich there and are treated as such. With lead ores, the concentration is continued until the ore contains 60% of lead. For a lead ore containing 20% of lead, 2% of oil will be necessary; for one with 30% of lead, 2½%; with 40% of lead, 3%; with 50% of lead, 3½%. As to the proportion of carbonate of lime, the instructions say: (524—447)

"It seems reasonable to assume that the proportion of the carbonate of lime follows practically the same rule, for a richer ore will require more gas than a poorer one."

I have quoted the above from the translation in evidence. My own translation from the French original would be as follows:

"It is logical to assume that the carbonate of lime follows
591 nearly in the same proportions, because a richer ore requires more gas than a poorer one."

The cost is, therefore, in proportion to the richness of the ore. The process of recovery is more suitable for a poor ore than for a rich one. It would be perfect, for instance, to treat sterile ore or half mixed ore or residues from the ordinary washing apparatus, especially when difficult ores have been treated by the washing apparatus.

The instructions return after this discussion to the process. The oiled ore is discharged from the mixing apparatus, which has been continually kept agitated during this operation, and then into a vessel provided with a coil. The agitator, with which the latter is provided, is then started at the rate of 10 to 12 revolutions per minute, so that the ore does not settle at the bottom in too compact a mass. A solution of sulphuric acid (containing 35% of pure sulphuric acid) is introduced into this mass through a leaden pipe. The vat should be filled with water to the level of the overflow. The lead pipe, which is provided for introducing the acid, has two branches, one of which is provided with a valve and it can be used for the admission of steam or water as desired. The quantity of sulphuric acid varies with the quantity of carbonate of lime, that is, it is in proportion to the latter, and for 1% of carbonate of lime 1% of concentrated acid, that is, about 3% of the dilute acid which Fro-
ment (525—448) mentions as suitable, should be used. As
592 soon as the acid begins to mix with the ore, the reaction, that is, the generation of carbonic acid, will begin and the gas bubbles will carry the greased sulphides to the surface. The concentrates are skimmed off or pushed into an overflow. The small proportion which again sinks to the bottom and is mixed with the gangue, can be, from the moment that the sulphide particles have been well oiled, easily separated on the purifying screen on which they will be subsequently treated. When no more gas bubbles pulling sulphides rise to the surface of the liquid, the gangue, containing a small quantity of sulphides which have remained in it, is gradually poured to the purifying screen. This screen should be worked by short jolts, about 200 per minute, and these jolts should be sudden and without duration. It has been found difficult to produce such repeated jolts by means of the eccentric of the experimental screen, which is easily understood. One must find it out by experience. On a manufacturing scale, the shaking of the screen is effected by a very simple apparatus, of which a sketch is given on a separate sheet. Owing to the jolts, the mixture of gangue and oiled minerals spreads uniformly in a thin layer on the screen. The oiled sulphide particles rise to the top, thus being able to reach the end of the screen, whilst the gangue passes through the heavy portion. The water which passes through the overflow of the screen enters into a filter case and
any of the sulphide particles which might swim on it are re-
593 tained therein. The concentrates might then be submitted to treatment in a hydraulic press or in a filter press, by which the recovery of a very large proportion of (526—449) the oil used may be achieved.

The apparatus as explained by the drawings and in the description, consists of a cylindrical centrifugal mixing device provided on the top with a hopper or chute for the introduction of the ore, and an oil pipe which is not shown in the drawing. The centrifugal mixing device contains two stirrers working in opposite directions, which are driven from a shaft provided with a driving wheel and make about 300 revolutions per minute. The contents of the mixing vessel are discharged through a pipe at the bottom of the vessel into two receivers, and from there into a vat with a coil, which is provided with a rake, a coil at the bottom having two branches at the end which is outside the vessel, a discharge pipe for the tailings at the bottom of the vessel, and a launder at the top. The purifying screen is fixed on a case in which there is a water pipe with a valve inserted so that the case can always be kept full of water. The moving of the screen is effected by a pulley and a shaft, and the screen itself, which is made of aluminum, is mounted on wood. The case in which the water is contained is provided at the end on the top with a pipe for discharging any light sulphides which might then fall into the filter.

At the bottom of the case there are discharge holes for the
594 residues, which are for dropping the residue into spitzkasten if it is desired to classify the residue. The screen is supported by wooden supports. The final part of the plant consists of a filter case, which contains four canvas filters, stretched on both sides over wooden frames and the space between the two canvas sheets is filled with charcoal powder. There is further an emergency discharge pipe provided. (527—450)

There is further a sheet marked "A," which illustrates the way in which provision is made for the jolting of the screen. This drawing is clear enough to speak for itself. It is to be noted from this drawing that the shaking screen is wholly immersed in water, as it is entirely below the liquid level determined by the overflow launder.

The leaden coil which is contained in the second vessel is perforated, the perforations being at the bottom of the coil. I mentioned that the coil ended at the outside and in two branches; an ordinary T, one branch of which is for the admission of sulphuric acid, the other for the admission of steam or hot water. There is no necessity for this T pipe except for cold countries, and it is clearly only provided to prevent the freezing up of the plant.

The working of the plant is obvious. The ore, limestone, water and oil are introduced into the centrifugal mixer, agitated thoroughly and then the ore passes after being mixed into two vessels which are stated to be for "receiving the ore after the centrifugal mixer," and from these vessels it passes into the vat provided with the
595 leaden coil. In this vat there is a rake or slow stirring device, which moves at the rate of 10 to 12 revolutions per minute.

"so as to prevent the ore from collecting at the bottom in too compact a mass."

Sulphuric acid, containing about 35% of sulphuric acid and 65% of water, enters into the body of oiled minerals and gangue at the bottom of the vat and generates carbonic acid, which gas carries the

oiled minerals to (528—451) the top, where they are either skimmed off or pushed into the launder, which leads them into a discharge hopper, and from there apparently to the filter case. Some of the oiled minerals which have been carried to the surface in the vat provided with the leaden coil, fall back and get mixed with the gangue and they are treated on the purifying screen, which, on being jolted, spreads the material uniformly over the screen in a thin layer and causes the oiled sulphide parts to rise to the top and to be carried forward to the end of the screen, from where they are removed by a discharge pipe. The gangue passes through the heavy portion and falls apparently through the screen into the bottom of the tank and from there it falls out through three holes into a system of classifiers, in which any part of the oiled mineral which may be mixed with them can be recovered.

The overflow from the tank provided with the screens and the overflow from the spitzkasten and the concentrates obtained from
596 the vessel provided with the leaden coil by means of the overflow, are all discharged into the filter case, the operation of which is self-evident and need not be described.

The concentrates may be finally subjected to a high pressure in a hydraulic press or in a filter press for the recovery of the oil.

The information contained in these instructions differs essentially from the matter which is revealed in Froment's specifications. It represents the experience which Froment had gathered by further investigation during the eighteen months which had elapsed between the date of the application for letters patent and the date when the instructions here were delivered to the complainants. (529—452) The patent describes only a test tube example. The patent is still under the ban of the Elmore buoyancy oil flotation and considerable quantities of oil are described as having to be used. The quantities of limestone to be used are very large, and as the limestone is for the purpose of generating the carbonic acid from it by means of sulphuric acid, the quantities of sulphuric acid are correspondingly large. The essence of the patent is the statement of a theory illustrated by a test tube test, and there is no description therein whatever even approaching a practical process. There is no process contained in the patent.

The instructions do describe a process and this process consists of two essential steps and of a number of other operations which are not Froment's inventions as far as his new process of concentration
597 is concerned, but only assist in the recovery of minerals from the tailings. This process consists of oiling the minerals in one vessel in such manner that when the agitated mixture is allowed to settle in a second vessel, the oiled minerals fall to the bottom (operation 1), and in lifting the oiled minerals in the second vessel in which they are very slowly raked like the soil in a garden by a rake making 10 to 12 turns per minute, whilst at the same time carbonic acid is generated. The carbonic acid carries the oiled minerals to the top and they are collected there. The principle involved is skin flotation assisted by bubbles of carbonic acid. The process revealed

by the instructions uses widely different quantities of materials from the quantities of the patent. The quantity of oil required varies roughly from one to three and a half parts of oil to one hundred of ore. The carbonate of lime is from one to two parts of (530—453) lime to one hundred parts of ore, and the acid is to be used in the same proportions as the limestone, namely, from one to two parts of concentrated sulphuric acid (66° Baume) to one hundred parts of ore. He specifies the quantities necessary to get the full benefit of the carbonate of lime, namely, to generate all the carbonic acid which is contained in a given quantity of limestone. There is a passage in the instructions which is rather obscure. Whilst in one place he stated the quantity of carbonate of lime to be used to be one part and the maximum to be two parts, to one hundred parts of ore, he says in another place that the carbonate of lime should be like the
598 oil in proportion to the quantity of sulphides and sulphuric acid in proportion to the quantity of carbonate of lime. The difference between the test tube example of the patent and the process of the instructions is as follows:

Test Tube Example of the Patent.

Quantities used: 10 grams of ore.
30 grams of water.
1.4 cc. of oil (at least).
1 gram of carbonate of lime (limestone).
1 gram of sulphuric acid concentrated.

All are filled into one test tube, then agitated for a brief space (one second in the Italian specification), the result being a "magma," that is, oil buoyancy flotation assisted by carbonic acid gas.

Process Revealed by Instructions.

(1) Ore de-slimed and mixed with water, one to three and a half per cent of oil, and one to two per cent of calcium carbonate, agitated at a speed of 300 revolutions per minute *of* about ten minutes. Result of agitation; oiled minerals with gangue at bottom.

(2) Mixture of No. 1, whilst being agitated, emptied (531—454) through intervening vessels into a vessel provided with a perforated leaden coil and a slowly acting rake for turning at a speed of 10 to 12 revolutions per minute the oiled minerals and gangue which had settled at the bottom of this vessel. Sulphuric acid introduced
599 through the perforated leaden pipe and carbonic acid generated, resulting to oiled minerals attached to gas bubbles floating to the top by skin flotation assisted by carbonic acid gas bubbles.

The result of the test tube example described in the patent is a magma consisting of oil, gas bubbles and mineral.

The result of the process revealed by the instructions is skin flotation assisted by gas bubbles.

Dr. Byrnes sums up the disclosures which, according to his view, are contained in this patent or in these patents. I agree with (2), that the use of a relatively small amount of oils is disclosed, if Dr. Byrnes means to express thereby that it is a relatively small amount as compared with the amount used in the process which was known at that time as the oil process of ore concentration, of which it is stated to be modification. If, however, Dr. Byrnes means to state as an absolute fact that small quantities of oil were used in the sense of what we understand a small quantity at the present time, then I disagree. I find the minimum quantity of oil to be 12½ per cent of the weight of the ore. I disagree with (3). Froment states definitely the quantity of limestone which he uses and as this limestone is only added for the purpose of supplying the carbonic acid to be used in this process, it reveals at the same time the quantity of sulphuric acid necessary to decompose the limestone and to liberate the carbonic acid (532—455) therefrom. I have explained that limestone is carbonate of lime and that it releases the carbonic
600 acid when acted upon by a stronger acid. If the definite quantity of limestone be given, the metallurgist knows at once the quantity of sulphuric acid necessary to liberate the carbonic acid. I agree with (4), with the addition that the brief space is defined in the Italian patent as one second, and in the English and Italian patents, Example 1, a few seconds for agitation and settling. I agree with it (6), "The consequent flotation of the sulfid, rising to the top of the liquid as a distinct magma," but disagree that it is a "froth." I have explained the difference frequently. A magma, according to Murray's dictionary, is any crude mixture of mineral or organic matters in a thin, pasty state. In the present case, it is a mixture of oil and minerals enclosing carbonic acid bubbles. A froth is a collection of gas bubbles surrounded by a liquid film on the surface of the liquid. I have the same objection to the use of the word "froth" in (7). Dr. Byrnes states:

"Thorough agitation is obviously necessary to distribute this small amount of oil thinly over the innumerable small particles of sulfid to be coated."

The patentee does not describe a small quantity of oil and I do not call 12½% of oil of the amount of ore a small quantity, and he does not describe thorough agitation. He says in the English patent that "the mixture is agitated for a brief space;" and in the Italian patent, "for a second." I do not call that "thorough agita-
601 tation." Dr. Byrnes then recites seven test tube experiments, the bearing of which on the Froment patents I do not understand. As to (1), namely, that 50 cc. of water being contained in a 100 cc. test tube and well (533—456) agitated, contained air bubbles which quickly disappeared, that is a well-known fact. Dr. Byrnes does not state how and for what period. As to (2), I cannot see the relation to the Froment patent, and the same may be said of (3) and (4). As to (5), Dr. Byrnes states that he added one drop of olive oil to a mixture, which has been gently heated, of 10 grams of Black Rock ore, 30 cc. of water, and a few drops of sulphuric acid, agitated for a brief space, "whereupon a large mass

of oiled and aerated mineral floated to the top, in the form of a magma or froth having the characteristics described in the Froment patent." I disagree with the result described, which I could not obtain, but again I cannot understand the bearing of this experiment on the Froment patent. The Froment patent does not describe the heating of the ore with sulphuric acid, it does not describe the addition of one drop of oil to the hot mixture thus prepared, from which no doubt most of the carbonic acid has been removed, it does not describe the thorough aeration of the liquid. Again I miss the duration of the agitation. If this experiment is meant as an experiment of the test tube example in the Froment patent then I distinctly say it is nothing of the kind. I have often mentioned the difficulty which is experienced by many people that they cannot separate themselves from the knowledge of the present
602 day and put themselves into the condition of the knowledge existing at an earlier time. It is impossible for me to conceive for what purpose this experiment has been introduced, as I cannot think that Dr. Byrnes meant to describe it as a Froment experiment. The purpose of experiment (6) is equally obscure and does not contain any contribution with regard to the Froment patent. Why Dr. Byrnes dissolved (534—457) two drops of cotton-seed oil in ether and poured this solution over 10 grams of ore, I do not know. If he thinks that it is a better way of distributing the oil over the surface of the ore, then I disagree, as this mode is not conducive to uniform oiling, and why he afterwards heated the ore thus prepared with 30 grams of water and sulphuric acid, is equally incomprehensible to me. The Froment test tube example is simple. Mix 10 grams of ore with one gram of calcite, and sulphuric acid, then a thin layer of oil, agitate for a second and the concentrates will be on the surface of the liquid in the form of a magma.

As to (7), the two experiments described in this, one of which is said to be Froment and I assume the other one an imitation of Froment, I say that neither of them is a Froment, and I further say that the description of a thin layer of oil as a few drops is incorrect and not in accordance with the facts. A thin layer requires at least 1.4 cc. of oil, which means, according to the size of the outlet of an ordinary pipette, anything from 49 to 63 drops. I repeat again that there is no warming described in the patent of
603 Froment and there is no warming necessary. As I said before, none of these test tube experiments are in accordance with the test tube example described by Froment, and none of them have any bearing thereon.

Dr. Byrnes states that he has "repeatedly operated the process of the Froment British patent 12,788 of 1902, using the Hyde slide apparatus to effect the brief agitation and frothing, and using different kinds of oil and widely differing amounts of oil."

There is no description of any apparatus in the Froment patent beyond the agitation of the test tube, and (535—458) there is no description of any frothing. The use of the slide machine is unwarranted and, what is more, it is impossible to produce the Froment result therewith. I have read the five experiments which Dr. Byrnes

describes as having been carried out with widely different amounts of oil. Before going into the details of the description and of the results, I should like to state here that the true test of these experiments is to try with the proportions of the quantities used by Dr. Byrnes, but according to the test tube example described by Froment. If they are in accordance with Froment, then the results which Froment describes must be obtainable by the test tube experiment.

In producing these experiments now, it must not be inferred that they are necessary to show that the experiments of Dr. Byrnes, in which he used the "Hyde slide machine," have nothing to
604 do with the Froment patent. I shall criticise Dr. Byrnes' experiments later on on their own merits. I believe, however, that it will be useful to the Court if I show by a translation of the quantities used by Dr. Byrnes to the corresponding quantities and proportions in which they would be used in the test tube experiments of Froment, the wide difference between Froment and Byrnes, the impossibility of deriving such quantities from Froment and the impossibility of obtaining Froment's result therewith.

492 grams of ore
.3 cc. of cottonseed oil
1 cc. (1.8 gram) of sulphuric acid.

If these quantities are translated into the quantities of the Froment test tube example, they are:

10 grams of ore
0.006 cc. of cotton seed oil
0.02 cc. (0.036 gram) of sulphuric acid.

(536—459) 0.006 cc. of cotton-seed oil equals about one-fourth to one-sixth of a drop of oil. We have no means of dealing with such quantities and I was compelled to use in this experiment a drop of oil. One-fourth to one-sixth of a drop of cotton-seed oil represents Dr. Byrnes' conception of a thin layer of oil in a 100 cc. test tube, which he in his experiments relating to the Froment patent used. 0.036 gram of sulphuric acid used by Dr. Byrnes represents one-half to one-third of a drop of sulphuric acid. It is equally impossible to convey this quantity into a test tube and it can only be done by diluting the acid with water and thus increasing the volume. No such description is mentioned in Fro-
605 ment and it was not necessary, as he deals with quantities which can be handled.

I took 10 grams of defendant's ore, which had been crushed in my presence to 80 mesh, mixed it with 30 cc. of water, added thereto 0.036 gram of sulphuric acid (which I had to dilute in order to be able to convey it into the test tube), and one drop of cotton-seed oil. As I said before, there are no means known of conveying the quantity used in Dr. Byrnes' above-mentioned experiment, and I was compelled, therefore, to use six times the quantity of oil that was used by Dr. Byrnes. I agitated them for about one to two seconds, with

the following result: practically all the ore was at the bottom, som slimes and oil, which could be observed by its glistening at the to (It will be remembered that in the instructions Froment says, thi the ore must be de-slimed for his purpose.) I repeated the agit tion for about seven seconds in a way which might be really calle violent agitation, but the result was the same as before describe namely, absolute failure to produce the Froment phenomenon d scribed in (537—460) his test tube example, namely, that the whol of the mineral will rise to the top of the liquid and form a magma.

The second example described by Dr. Byrnes has been made wit the following quantities:

492 grams of ore
20 cc. of cotton-seed oil
1 cc. (1.8 grams) of sulphuric acid.

606 These quantities, when translated into the quantities o the test tube example, are

10 grams of ore
0.4 cc. of cotton-seed oil (14 drops)
0.02 cc. (0.036 gram) of sulphuric acid ($\frac{1}{3}$ of a drop).

These quantities were mixed, as described in the previous e periment, and the mixture was agitated for two seconds. The resu was identical with the one of my previous experiment. Practicall all the ore was at the bottom of the liquid, some oil containing som slimes on the top. Even after further vigorous agitation for fiv seconds the result was not altered.

The next experiment of Dr. Byrnes is identical with the previou one, with the exception that he uses 20 cc. of Ehrmann's Californi olive oil instead of cotton-seed oil, and my experience was identica with my previously described one, with the exception that I use 0.4 cc. of Ehrmann's California olive oil instead of 0.4 cc. of cotton seed oil, and the results were identical with the results of the pre vious experiment, both after shaking from one to two seconds and after shaking for a further seven seconds.

The next experiment of Dr. Byrnes is identical with the second experiment, with the exception that he used 20 cc. of defendant's "red oil," and my experiment was identical with my second experiment above described, with (538—461) the exception that I used 0.4 cc. of oleic acid, and the results were identical with the results of the two previous experiments, both after shaking for one to
607 two seconds and after shaking for a further seven seconds.

The last experiment of the series presented by Dr. Byrnes contains a slight variation in the proportions, namely:

500 grams of ore
10 cc. of red oil
1 cc. (1.8 gram) of sulphuric acid.

The corresponding proportions used by me in a test tube experiment were:

10 grams of ore
0.02 cc. (0.036 gram) of sulphuric acid
0.2 cc. of oleic acid.

The experiment was carried out in the same way as the first experiment and the result was the same as described *of* by other experiments of this series.

The conclusions from these experiments are that it is impossible to produce the Froment result with the proportions between ore, oil and acid which Dr. Byrnes used in the slide machine experiments, and I say deliberately that it is impossible with such proportions to produce the Froment result of the test tube example, namely, causing the whole of the mineral to rise instantly to the top of the liquid in the form of a magma. It is obvious and self-evident from the result of these experiments that Dr. Byrnes' experiments cannot be in accordance with and are not the invention revealed in the Froment patent.

I will now return to the experiments of Dr. Byrnes. I have calculated the recovery of zinc obtained in each experiment, the amount of zinc left in the tailings, and I have ascertained
608 the loss if there was any occurring in each experiment. In the first four experiments, the (539—462) quantity of ore used contained 99.9 grams of zinc.

In Experiment 1, Dr. Byrnes recovered	85.25	grams
The tailings contained	13.25	"
	98.50	grams

and there was, therefore, a loss of 1.4 grams.

In Experiment 2, Dr. Byrnes recovered	101.9	grams of zinc
The tailings contained	2.9	
	104.8	grams

Dr. Byrnes, therefore, recovered 4.9 grams more than was contained in the original ore. The margin is rather wider than is usually allowed for errors in the analysis.

In Experiment 3, Dr. Byrnes recovered	97.0	grams
The tailings contained	1.6	"
	98.6	grams

and there is, therefore, a loss of 1.3 grams.

In Experiment 4, Dr. Byrnes recovered 27.4 grams.

The tailings were not assayed.

There is, therefore, in this experiment a loss of 72.5 grams.

In Experiment 5, the zinc contained in the quantity of ore used was 101.5 grams.

609 Dr. Byrnes recovered.....95.9 gram
The tailings contained..... 3.1 gram

99.0 gram

There was, therefore, a loss of 2.5 grams.

I will recall the fundamental idea on which Froment based his invention. A gas generated in the nascent state will cause mineral moistened by oil to rise to the surface of the liquid. He describes as such gas carbonic (540—463) acid and he generates it in the nascent state by the action of sulphuric acid on limestone. Metallic carbonates, it may be generally stated, are capable of evolving carbonic acid on addition of sulphuric acid. But the conditions necessary to produce the reaction may vary and do vary widely. The celerity of the reaction depends on a number of factors, namely, whether the carbonate is soluble in the medium in which it is exposed to the action of the acid, whether if soluble it is presented in the very finest powder to the action of acid, whether even if finely powdered the small particles have a crystalline structure or whether they are amorphous, whether they are individual particles or whether they are enclosed within some other substance resisting the action of the acid. All these factors are of great importance and the rapidity or slowness of the generation of carbonic acid will depend on the selection of a suitable carbonate. Rhodochrosite which is chemically manganese carbonate, is not readily attacked by sulphuric acid and it requires warming when mixed with
610 a liquid before sulphuric acid will generate carbonic acid from it. I have found that in the state in which it is contained in defendant's ore, even if the ore is crushed to an 80 mesh it is not readily attacked by sulphuric acid at a temperature of 40° Centigrade (104° Fahrenheit), and Dr. Byrnes observed the same fact. He states in Experiment 4,

"and the mixture was gently heated, whereupon gas was chemically liberated by the action of the acid on the carbonate."

The mixture to which the sulphuric acid had been added consisted of 10 grams of Black Rock ore finely powdered and contained in 30 cc. of water, to which, as described in (4), sulphuric acid had been added. The same fact is (541—464) described again in Experiment 6, in which 10 grams of oiled ore were mixed with 30 grams of water. 5 grams of sulphuric acid were added to this mixture and

"the whole was gently heated to cause the sulphuric acid to react on the carbonate in the ore."

And the same fact is described in (7) of this series of Dr. Byrnes' experiments, in which he stated,

"On warming to start the reaction."

Dr. Byrnes represents the experiments made in the slide machine as experiments falling under the Froment patent. The result must, therefore, be due to the generation of carbonic acid by the action

of sulphuric acid on the rhodochrosite contained in defendant's ore, which he used in these experiments. I am sure, from experiments which I made that scarcely any action of sulphuric
611 acid on the rhodochrosite can have taken place. It is further a fact that, if the whole of the sulphuric acid had been used up in Dr. Byrnes' experiments, it would be utterly inadequate to produce the result which has been described by Froment. 1 cc. of sulphuric acid represents in weight 1.8 grams, and it is capable to produce 0.8 grams of carbonic acid. 0.8 grams of carbonic acid represents in Volume 0.4 of a litre. The solubility of carbonic acid in water of ordinary temperature is one volume of carbonic acid in one volume of water. Dr. Byrnes used in his experiments 1700 cc., equal to 1.7 litre of water which at ordinary temperature is capable of dissolving practically four times the quantity of carbonic acid which could have been generated if all the sulphuric acid had been consumed. Twice the amount of carbonic acid would have been practically dissolved by the amount of water if the temperature had been 50 Centigrade instead of ordinary (542—465) temperature or the temperature of 70° Fahrenheit, which is 21° Centigrade, which Dr. Byrnes used. The agitation in the slide machine would assist the solution of the carbonic acid in water considerably and would put it practically out of action for the purpose and the duty which Dr. Byrnes alleges it performed. In the first of his experiments, Dr. Byrnes used a quantity of oil, namely .3 cc. (.27 gram), for 492 grams of ore. That is roughly, 1.1 lb. per short ton of ore. I cannot conceive the reasons which induced Dr. Byrnes to describe this experiment as an experiment conducted according
612 to the Froment patent. It differs in principle, in proportions and in the mode of carrying out absolutely from anything which is revealed in the Froment patent. As a matter of fact, it is nothing but the production of the agitation froth carried out according to the process of the patent in suit, such process being understood to mean an agitation such as will commingle air with a mixture of ore pulp with a quantity of oil such as described in the patent in suit in the presence of a small quantity of sulphuric acid. Dr. Byrnes describes in this experiment, which he characterizes as a Froment experiment, that he collected five froths (I will not repeat again and again that Froment does not obtain a froth). I fail to find in the Froment patent anything which could possibly induce a metallurgist to effect the recovery of the mineral by five repetitions of the froth production experiment. On the contrary, Froment states twice that in one operation the whole of the mineral is removed from the ore (Froment British Spec., p. 2, lines 37, 38, and p. 3, lines 4-6):

"the whole of the copper pyrite will instantly rise to the top of the liquid."

"Only a few seconds were necessary for (543—466) completely separating the sulphide of copper from the rest of the gangue in which no single trace of copper could be discovered by analysis."

I repeat that Experiment 1 is nothing but the performance of the process of producing the agitation froth of the patent in suit.

613 The Experiment 2 differs from 1 that sixty-six times the amount of oil was used therein. The other parts of the mixture, namely, water, acid and ore, are the same as in Experiment 1. All the facts which I stated with regard to Experiment 1 apply therefore with equal force to this experiment. It can never be considered a Froment experiment. The quantity of oil in Experiment 2 is considerably larger than the quantity used in Experiment 1. It amounts to 72 lbs. of oil per short ton of ore. The concentrates produced on the surface of the liquid are both in appearance and character entirely different from the agitation froth of the patent in suit. The oily character of the minerals is clearly visible to the naked eye. I should describe it as a mixture of oil, minerals and air bubbles. My conclusions are the same as derived from the first experiment. The oil quantities are not Froment's quantities; the acid quantities are utterly different from Froment's quantities, and the principle involved is utterly different from Froment's principle. It is the application of an agitation resulting in commingling air with the pulp, oil and ore, which has been for the first time consciously stated in the patent in suit for the purpose of concentrating ores by means of a froth. I need scarcely add that the quantities of oil used in the second experiment render it perfectly useless for manufacturing purpose by reason of the expense for the concentration of ores, even if the concentration were as good as described in this experiment. (544—467)

614 The same remarks and criticisms apply equally to the other three experiments.

Experiment No. 4 shows rather exceptional results, as the recovery by three repeated operations, or, as Dr. Byrnes calls it, by three froths, amounted only to 27.4% of the whole zinc contained in the ore. In Experiment 5 Dr. Byrnes obtained by the collection of four froths (his term) the recovery of about 95% of the zinc contained in the ore. Dr. Byrnes seems to explain the difference in these two results by the fact that in Experiment 4 "red oil," or, as he calls it, "impure oleic acid" was used, whilst in Experiment 5 a pure "red oil" has been used, that means, a "red oil" which contained less of the solid fatty acids, namely stearic and palmitic acid. I have analyzed two specimens of defendant's oleic acid, one marked "Specimen 2 of Defendant's Oleic Acid," and which was received by me, through counsel, from Dr. Byrnes as a specimen of the ordinary "red oil" which he had used in his tests, and the other marked "Defendant's Purer Oleic Acid," which was received by me, through counsel, as a specimen received by him from defendant of the purer "red oil" used by the defendant and by Dr. Byrnes in the experiments described in their testimony. The result of this analysis was that these two oils are identical in the amount of palmitic and stearic acid they contain. Both of them contain the same quantity of oleic acid and the same total quantity of palmitic and stearic acid.

615 The result of this analysis excludes the reason by which Dr. Byrnes seems to explain the difference in result of re-

covery according to Experiment 4 and of Experiment 5, to which might be well added the other experiments.

In the experiment which I carried out in the test (545—468) tubes, translating the quantities used by Dr. Byrnes with the slide machine into the corresponding test tube quantities, I have stated that for the 4th and 5th of such experiments I used oleic acid. I did use oleic acid for the following reasons. Dr. Byrnes states, in the last of the experiments quoted:

"It should be noted that the 'red oil' used in this test was a special or somewhat purer form of oleic acid than that used in the preceding run, more of the solid fatty acids, stearic and palmitic, having been removed by the maker, Charles T. Perry & Co., rendering it thinner and less viscous, pasty or solid at ordinary temperatures."

I have stated that the analysis of the oil in question proved his conclusion to be erroneous. I would, however, have taken this oil for these experiments, if not unfortunately the glass bottle which contained it had been broken on the journey from England to this country. In order to satisfy the criticism and objections which Dr. Byrnes offered with regard to the oil which he calls a more impure oil, I selected for use in this experiment a commercial oleic acid which did not contain as precipitates solid fatty acids, stearic, and palmitic acids, at ordinary temperatures, and it was free from
616 the objections which Dr. Byrnes seems to attribute the bad concentration results of the first experiments with "red oil."

The analysis which I carried out with the two "red oils" obtained from counsel, as stated before, proves that Dr. Byrnes' explanation of the bad result of concentration of the first experiment with that "red oil" is not borne out by the facts. My explanation is that, in the initial operations, a large quantity of oil may have been removed and that, therefore, in Experiments 2, 3 and 5 of this series, proportions between oil and ore were created falling within the proportions revealed in the patent in suit, just as (546—469) the proportions of Example 1 of the series are the proportions of the patent in suit.

I have calculated the quantities of oil revealed and used in these experiments of Dr. Byrnes for a ton of ore, and equally so the lowest quantities of oil which I have found by actual estimation disclosed in Froment, and I state the results in the following table:

Dr. Byrnes' Experiments.

No. 1, the quantity of oil 1.1 lbs. per short ton of ore; 2, 3 & 4, quantity of oil 73 lbs. per short ton of ore; 5, quantity of oil 36 lbs. per short ton of ore;

Froment British Patent No. 12,778 *of* 1902.

Smallest quantities of oil 250 lbs. per short ton of ore.

In complainants' patent in suit the quantity of oil "found suitable and economical" is 2 lbs. of oil per short ton of ore. This quantity

may be varied, it may be lower or higher, but the amoun
617 stated has been in the experience of the patentees a suitabl
and economical quantity.

The quantities of oil used by Froment and the quantities of oi
used by Dr. Byrnes in his experiments 2, 3, 4 and 5 would render any process in which they were used valueless for commercial purposes. Ore concentration carried out, even with much smaller quantities, for instance, with the quantities which Cattermole described in his specification, were fatal to the commercial success, even if otherwise producing satisfactory results. Figures will be the best illustration. If the price of oleic acid were 5 cts. a pound, the cost involved for the treatment of one short ton of ore would be, for the quantities which Dr. Byrnes used,

For Experiments 2, 3 and 4..... $3.65
For Experiment 5..... $1.80

(547—470)

For Froment $12.50
For Complainants' patent in suit..... .10

It is true that in processes such as Froment's or as described in Experiments 2, 3 and 4 of Dr. Byrnes, part of the oil would be recovered, but such recovery would involve expense. Furthermore, only part of the oil contained in the concentrates can be recovered as such. A considerable amount remains in the concentrates. But concentrates with such amount of oil would be unsalable and this remnant has to be removed by chemical agents, which again is a costly operation.

I have stated that the oil which is left in concentrates
618 cannot be all removed therefrom, even by high hydraulic pressure or by filter presses. A considerable amount remains. I have estimated the amount, that is, I have ascertained the amount by analysis, and I have found that, after exposing a mixture of oil and concentrates to the highest pressure that I could produce, which pressure was far in excess of the pressure obtainable by filter presses, the amount of oil left in the concentrates to be 9% in weight of the concentrate. It is possible to remove such quantity by after treatment with chemical agents, if the oils belong to the class of vegetable or animal oils. In such case, a treatment with caustic alkali will dissolve them, but naturally there is the cost of the chemical agent and the cost and working expense of this treatment to be added to the first expense. The oil is obtained in a form commonly called soap, and to recover it for the purpose of use in ore concentration, it must be treated with acids. A soap is like a carbonate, a salt. That means, the combination of an acid with a metallic base. (548—471) In carbonates the acid is carbonic acid. In soaps the acid is a fatty acid like oleic acid. By the action of the stronger acid on soap, the metallic base contained in soap combines with the stronger acid and the fatty acid is liberated in this process. This operation again involves cost for chemical agents and additional working expenses. If fatty oils, such as olive oil or cotton-

seed oil, have been used, it is impossible to recover these by the treatment with alkali. They would be decomposed and
619 converted into fatty acids by such treatment. The only treatment would be to extract them with solvents, which is quite out of the range of a process like ore concentration. The cost would be enormous and the result would be again that instead of losing the oil, a portion of the solvent would be lost. What is more, the solvents su[illegible]e for the purpose are of a highly inflammable character and wo[illegible] be dangerous to use. If heavy mineral oils remain in the concentrates, they cannot be removed by caustic soda in any form and they have to remain in and are a loss. They could be removed by extraction with other solvents, but that process is quite out of the question and impossible, both on the consideration of cost, which would be enormous, and owing to the inflammability and danger of the extracting solvents which would have to be used. It is a fact that any process of ore concentration, which results in the leaving of considerable quantities of oil in the concentrate, will be highly costly, even if part of the oil can be recovered by filter process or hydraulic presses.

I have stated what, in my view, is the true reading of the Froment specification, No. 12,778 of 1902, and what is revealed therein. Dr. Byrnes has not produced a (549—472) single experiment which can be called an experiment truly carried out according to the Froment patent. His test tube experiments have nothing whatever to do with it. His slide machine experiments have nothing whatever to do with it. I have not repeated them. I have not con-
620 sidered it wise to chase these hares which have been pushed into our road to detract attention from the real issue of this case, to complicate its simple issues and to confuse them. Dr. Byrnes states that he has produced in the first experiment of the series a froth of concentrates. There is nothing surprising in this. He used the process which for the first time in the history of ore concentration was revealed in the patent in suit, and he practically used the quantities which are described therein as being suitable and economical. He commingled, by brisk agitation, air, ore and traces of oil, traces so small that they cannot be translated into the test tube experiments of Froment. He produced the agitation froth. He did not learn that from Froment, but he learned it from the patent in suit. He then used the same process with very much larger quantities of oil and states again that he obtained a froth. There may be what is popularly called a froth, but this froth differs in characteristic qualities from the froth produced with the quantities of oil described by the patentees of the patent in suit as suitable and economical. It contains large quantities of oil which are quite visible and can even be detected by the touch. The appearance of the minerals is changed. They have a dull look and lack the metallic lustre of the minerals. The agitation froth produced with the quantities of oil which the patent in suit informs you are suitable, does not disclose the presence of any oil. The faint traces of oil

which must be there are absolutely invisible and only
621 (550—473) careful chemical analysis can show their pre
ence. To the touch the concentrates thus obtained are t
same as the ordinary mineral which had never been treated wi
any oil. I cannot understand why Dr. Byrnes produced the
experiments. He only proves that he can produce, with much larg
quantities of oil than are considered economical by the patent i
suit, a froth, but at the same time he proves that the quantiti
recommended as economical in the patent in suit are economica
It frequently occurs in patent litigation that a defendant will mak
an untenable defense by alleging that he produces a result by di
ferent quantities, sometimes by much larger quantities, but, o
course, such a defense must always fail. It is no defense to use th
essence of the invention and produce only a result which increas
the cost of production in such an enormous way as the cost woul
be increased if quantities of oil were used such as described i
experiments 2, 3, 4 and 5 of Dr. Byrnes' alleged Froment sli
machine tests. I have stated my views on the Froment patent an
on the Froment instructions fully, and I need only repeat once mo
that there is nothing contained therein which would enable anybo
to produce the agitation froth of the patent in suit, and, furthermo
that there is nothing contained therein which might lead an i
vestigator even in the direction of the invention of the patent
suit. (551—473*a*)

(The following testimony of Dr. Eugene A. Byrnes was then re
to the witness:)

"Froment, as I have noted, confines his description to th
622 process and its principles, leaving the type of agitator to
determined by the user. In his test-tube experiment, agit
tion sufficient to coat the mineral particles with a thin film of th
oiling agent also thoroughly aerates the mixture, the fine bubbles o
air distributed throughout it, and attaching themselves to the oile
particles, acting with the chemically-evolved gas to float them."

The first sentence of this quotation is utterly wrong in the mai
statements, and it is only true in one fact, namely: that Fromen
describes some principles. There is no process described, only a te
tube example, and as for the fact that he leaves the type of a
agitator to be determined by the user, that is only a wild flight o
imagination. I said there is no process described, and the wor
"agitator," as referring to the commercial process, does not occu
in the specification.

The second sentence is not correct. The British patent states tha
a mixture of ore, oil in substantial quantities, limestone, water an
sulphuric acid is to be agitated for a brief space, and further on says

"Only a few seconds were necessary for completely separating th
sulphide of copper from the rest of the gangue in which no sing
trace of copper could be discovered by analysis."

The Italian patent makes the same statements, except that it say
"a second," instead of "a brief space." There is not a sing
623 word contained in the Froment patents referring to aeratio
and what is more, I have proved definitely that it is impo

ible to produce aeration according to the test tube experiments described by (552—474) Froment. If Froment had had any conception of aeration, he certainly would have described it. It is not the case that the mineral particles are floated by air. They are floated by the carbonic acid generated in the nascent state in the mixture. This is the whole of Froment's disclosure, and this is all that results from testing his disclosures.

I have tested the Cattermole process as applied to defendant's ore and have carried out three experiments with regard to it as follows:

1. I used 400 grams of defendant's ore which had been crushed in my presence to 80 mesh, and made a pulp with 1500 cc. of water containing 0.25% of sulphuric acid. To this pulp I added 7.3 grams of oleic acid, which corresponds to 6% of oleic acid on the zinc sulphide contents of the ore, and 1.8% on the ore. The whole mixture was contained in a cone mixer or Gabbett and was agitated for ten minutes. It was then, whilst being agitated, emptied out into a classifier, in which an upcurrent of water was maintained. The slimes separated in the overflow, whilst the granules fell into a bottle which was fixed at the bottom of the classifier. After the contents of the cone mixer had been completely emptied out and treated in the classifier, the bottle was withdrawn and the granules filled into another bottle, which I marked "Cattermole Granules 1."

624 2. 500 grams of defendant's ore, the same as described in Experiment 1, were made into a pulp with 1500 cc. of water containing .25% of sulphuric acid, and 9 grams (553—475) of oleic acid (6% on the zinc sulphide content of the ore, and 1.8% on the ore) were added thereto. The whole was agitated for ten minutes in the same cone mixer. It was then introduced in the same manner as described in Experiment 1 into the classifier. The granules thus obtained were put back into the cone mixer and the same quantity of water containing 0.25% of sulphuric acid was added to them, and the mixture of water and granules was agitated for ten hours. The granules were then collected in a classifier, as before described. Then they were filled into a bottle, which I marked "Cattermole Granules 2."

3. 400 grams of the same ore were mixed with 1500 cc. of water containing 0.5% of sulphuric acid and 8½ grams of oleic acid (7% on the zinc sulphide content of the ore) were added. The mixture was agitated in the cone mixer for ten minutes and the granules were then separated in the classifier, as before described. The granules thus obtained were put back into the cone mixer and the same quantity of water was added as was originally used. The baffles were then removed and the mixture was agitated for nine and a half hours. The granules were then collected in the same way as before described in a classifier, and a number of the larger ones filled into a bottle, which is marked "Cattermole Granules 3." This experiment was carried out according to the alternate method given

625 on page 3, line 46, of the Cattermole patent:

"With certain ores it may be preferable to use in some stages of the process a rolling form of agitation, as in cylinders or barrels, to obtain good granulation of the mineral." (554—476)

The mode of preparing the specimen "Cattermole Granules is in accordance with the process which would be worked on a ma facturing scale. Experiments 2 and 3 were carried out with intention of securing very hard and lasting granules to be used exhibits, and for this purpose the rolling was continued for nine a a half to ten hours. These latter two experiments are not intend to represent the working of the process as carried out in ma facture.

The three specimens produced by the witness were offered in e dence and marked, respectively:

"Complainants' Exhibit Cattermole Granules 1"; "Complainan Exhibit Cattermole Granules 2"; and "Complainants' Exhibit C termole Granules 3."

It is true that the patent in suit makes use of the well-kno property of minerals that they have an affinity for oils, whilst t gangue practically repels the oils. It has been stated in this eviden that this fact is as old as at least Herodotus. Anyhow, it was clea established in Haynes' specification applied for in 1860, and si then a number of attempts have been made to solve the diffic problem of ore concentration by this method. They have
626 failed, although two of them, namely, Elmore and Catterm have been practically used. They disappeared as soon the new invention which forms the subject matter of the patent suit, was made. The patent in suit was the final solution of a pr lem to which, as the number of patents offered by the defend proves, a great many inventors had applied their ingenuity, (555 477) their energy and time and labor, and had been unable accomplish the result. It happens frequently so with great ventions. The results are not obtained suddenly. Very often large number of years pass by, every year containing a contributi which remains sterile, until finally the right way is found and t world enriched thereby. I need only mention the Tungsten filamen Efforts of very great men have been directed for over thirty yea to make a metallic filament of tungsten. All kinds of methods we used, but the results were futile. Only in 1905 the problem w solved and the carbon filaments, which formerly were the on ones used, practically disappeared altogether. The arrival of t tungsten filament signified great economical progress. In the sam way, the arrival of the process of the patent in suit signified gre economical progress in the mining industry. Inventions are scarce ever revelations of new laws. Such an invention is an event to remembered. In nearly all inventions, even those of the greate importance, the old methods are used and new facts establish thereby, which are beneficial to the community. Wirele
627 telegraphy depends on the production of Hertzian waves di covered by the great successor of Prof. Clausius at Bon Marconi only found a receiver for these waves. But is this inventi less great, less beneficial and less important because Marconi us the Hertzian waves? Herodotus, or, to mention the later invent Haynes, found the preferential affinity of minerals for oils. Car Everson discovered that that preferential (556—478) affinity w

ndered more valuable and more pronounced if acid was present an ore pulp. The gangue thereby was prevented from any attachent to the oil. But does that take away from the merit of the tentees of the patent in suit? Does it do away with the fact that ey enriched the world with a new, valuable and greatly successful ocess for ore concentration, which many had attempted before, t which none had succeeded in?

The patent in suit refers to certain Cattermole patents, then states e invention, and then recites the factors assisting the invention. ne of these factors is a slight acidification of the water in which e oiling is effected. This statement is as follows:

"Thus the water in which the oiling is effected is preferably slightly idified by adding, say, a fraction of one per cent up to one per cent. f sulphuric acid or other mineral acid or acid salt." (Spec. p. 1, nes 36—40).

This statement of the patent is quite correct. The addition of acid is not for the purpose of generating a gas. It is simply to
28 prevent the gangue from being coated with the oily substance, and the further statement

"the proportion of acid used is insufficient to cause chemical action n the metalliferous minerals present,"

also true, as I have experimentally proved. An ore containing inc sulphide and galena was subjected to the action of sulphuric acid f a concentration such as specified, for some time, and no zinc was ound in the solution. If the acid had acted on the zinc sulphide, inc would have been discovered in the acid solution. Lead sulphide r galena cannot be attacked by sulphuric acid (557—479) under uch conditions; that is a well-known chemical fact.

The patent then enumerates the conditions which assist in the ealization of the discovery, warming of the mixture of the pulp, fine ulverization of the ore and the fact to which the patentees specially raw attention that the slimy mineral most readily generates scum nd rises to the surface. The amount of mineral recovered by flotaion of the froth is said to vary with different ores and the recovery lso varies with different oily substances, necessitating a preliminary est to determine which is most suitable for the particular ore. This s really a warning that it is impossible to describe in a document uch as a patent specification the details of a process which is capable f being carried out with every one of the innumerable ores in exstence. The patentees only can give examples and the essence of the invention, but, as they say, a simple preliminary test, now
29 the facts are known and the new process described, will give you the information which is required. The specification then ives a specific example, as Dr. Byrnes admits. An important statement of the specification should be here considered.

"The minimum amount of oleic acid which can be used to effect he flotation of the mineral in the form of froth may be under 0.1 er cent of the ore; but this proportion has been found suitable and conomical."

This statement is of significance. Even at the time when th inventors could have only a comparatively small experience, the found the proportion of oil in quantities (558—480) of 0.1 per cen to one hundred parts of ore suitable and economical. In the numbe of years which have passed since the filing of this specification th experience has been confirmed, and proves the power of exact an careful observation of the patentees. In the description of this ex ample, the patentees also called attention to the fact that the powe of flotation of the froth is mainly due to the inclusion of air bubble introduced by the agitation. That is quite correct. In the forme attempts, it was the reduced specific gravity of a mixture of larg quantities of oils with minerals, sometimes assisted by the inclusio of air or gas bubbles, to which the flotation was due. These were th oil buoyancy flotation processes. In the agitation froth process, th oil, although specifically lighter than water, is present in such smal quantities, in quantities which I called before infinitesimal a
630 compared with the quantities of oil used formerly for flota tion processes, and infinitesimal as compared with the quan tity of mineral which they have to coat, that it scarcely plays an part in the flotation of the minerals. The flotation of the minera is mainly due to the inclusion of air bubbles.

I would also call attention to the following statement of the spec fication on page 2, lines 40—45 of the patent in suit:

"The proportion of mineral recovered in the froth and that r covered by table flotation may be considerably varied; but, generall speaking, the froth will separate the slime mineral while the large particles are recovered by the latter method."

This statement is very important, as it foreshadowed (559—481 the possibility of a grinding of the ore which would render unneces sary the supplementary treatment of the tailings described in th patent remaining at the bottom of the spitzkasten. This forecas has been realized in the practical working of the agitation-froth pro cess. The grinding of the ore is carried out in such manner tha practically the whole of the mineral is recovered therefrom by the agitation-froth process and no other treatment is required for the tailings; they are left clean. This statement is further important in this respect. By no other practical process, with the exception of Cattermole, slimes could be treated. In the process of the pat-
631 ent in suit, not only can slimes be treated, but the presence of slimes is highly beneficial.

It is a suitable place here to give my experience of the working of the patent and to describe such experiments which will be of assist ance in showing that the statements made in the patent are correct. I have seen the process carried out several times in the plant at the works of Minerals Separation, Limited, in London. This plant is capable of treating fifty tons of ore a day of twenty-four hours. It is practically the same as that shown in the drawings "Complainants' Exhibit, King John's Court Standard Plant," with the exception that another spitzkasten has been added in front of the agitating box marked 3, so that there are six spitzkasten, instead of the five shown

the drawings, and that the deflector F was not present. I saw on the spitzkasten large quantities of the froth, which I have characterized before, sometimes (560—482) three or four inches deep. I have also made numerous tests in the slide machine and in the cone mixer or Gabbett, and I have used for these tests different ores and different oils. I usually succeeded with the quantity of oil, namely, 0.1 per cent, which is recommended in the patent as "suitable and economical." In one instance I found the addition of .025 per cent to .1 per cent, making a total of .125 per cent, was necessary for the production of a good froth. This was with palm oil. With linseed oil I got the best results with .2 per cent.

I tested also the statement that the power of flotation of the
632 mineral as a froth is due to the inclusion of air bubbles introduced by the agitation. The way to determine the accuracy of this statement is very simple. The gases contained in the froth are collected in a bottle and are then subjected to gas analysis. A suggestion has been made by the defense that the gas which causes the formation of the froth was carbonic acid and not air. In order to prove finally and definitely whether air or carbonic acid is the agent which effects the formation of the froth, I selected the conditions carefully in such way that I was bound to find the maximum amount of carbonic acid which could participate in the formation of a froth. I collected, in experiments which were made with the fifty-ton plant in the works of Minerals Separation, Ltd., the gases from the froth appearing on the first spitzkasten, where, if there is any carbonic acid formed at all, most of it must collect. In one test the gases collected from the froth resulting from the treatment of an American copper (561—483) ore showed 98.7 per cent of air and 1.3 per cent of carbonic acid. No acid had been used in the treatment of this ore and the 1.3 per cent of carbonic acid must have been obtained from the atmosphere. In another experiment, in which Broken Hill tailings were submitted to the process of the patent in suit, 96% of air was found and 4% of carbonic acid. A third sample of gas, which was collected at a different time but from the same ore, namely, the American copper ore, referred to in the description of my first test, showed on analysis 98.8% of
633 air and 1.2% of carbonic acid. It will be remembered that no acid had been used in this process. Carbonic acid is always present in small traces in the atmosphere and more so in places where illuminating gas is continuously used, like in the works of Minerals Separation, Ltd. I made further a number of gas analyses of gases collected from froths which were obtained according to the process of the patent in suit in the slide machine. The narrow confines of this machine would result in showing the utmost quantities of carbonic acid which could be present in any froth. I used a sample of defendant's ore which had been treated with acid for eighteen hours for the purpose of showing that none of the values had been attacked thereby. The treatment was as follows: 400 grams of defendant's ore, crushed in my presence, were made into a pulp with 1000 cc. of water, and 9 grams of sulphuric acid were gradually

added thereto in quantities of one gram at a time. Then the mixture was allowed to stand for eighteen hours. The ore (562—484) was collected on a filter, washed thoroughly until neutral, and was then used for the production of a froth according to the patent in suit. The acid added was in the ratio of 10 lbs. per ton of ore. The analysis of the gas revealed the presence of 97.1% of air and of 2.9% of carbonic acid. In another experiment I used the ore marked "Defendant's Feed to Flotation Plant." The froth was produced without the addition of acid and the gas collected from it consisted of 100% of air. No carbonic acid was found. Another sample of
634 gas collected from a froth produced by the process of the patent in suit from the ore marked "Defendant's Feed to Flotation Plant," in which production sulphuric acid had been used with a ratio of 10 lbs. to the ton of ore, showed as a result of analysis the presence of 90.7% of air and 9.3% of carbonic acid. Another sample of gas collected from the froth produced from a French ore in the presence of sulphuric acid (ratio 10 lbs. of acid per ton of ore), showed an analysis 98.8% of air and 1.2% of carbonic acid. I also collected a sample of gas from a froth produced according to the process of the patent in suit from a San Francisco del Oro ore, in the presence of sulphuric acid (ratio 60 lbs. of acid per ton of ore). This ore is distinguished by the fact that it contains from 4 to 5 per cent of limestone. The analysis of the gas showed the presence of 77.5% of air and 22.5% of carbon dioxide.

It is clear from these analyses that the statement of the patentees is perfectly correct, that it is even correct in the abnormal circumstances which occur in the San (563—485) Francisco del Oro ore, which contains an extraordinary amount of limestone, and, therefore, an extraordinary opportunity for the generation of carbonic acid. It will be noticed that in this experiment I added six times the amount of acid that was used in the other experiments. It was made by me because I wanted to find out the largest quantity of carbonic acid which could be obtained in the gases present in the
635 froth. All the experiments were made at a temperature of 55° centigrade, so that I would have as much carbonic acid as possible in the gaseous form and not in solution in the water. Carbonic acid is soluble in water at ordinary temperatures in the ratio of one volume of carbonic acid to one volume of water. At 55° centigrade (131° Fahrenheit), the solubility of carbonic acid gas in water is at the ratio of less than half a volume to one volume of water, and at this temperature, therefore, a much larger quantity of carbonic acid can be in gaseous form than at ordinary temperatures.

I repeat that the statement of the patentees that the froth derives

"its power of flotation mainly from the inclusion of air-bubbles introduced into the mass by the agitation"

is perfectly correct. I have explained before that, in my view, the word "mainly" refers to the carrying power of air as contrasted with the carrying power of the small quantity of oil present. It might be said that the gas contained in the froth consisted mainly of air and

some traces of other gases. But the statement is correct, whichever explanation might be preferred. (564—486)

My examination of the patent, which I have made as thoroughly as possible, has shown me that the patent contains a valuable invention, that the invention is fully described and does not offer any difficulties in its performance, and that the facts stated are accurate. I can quite understand the remarkable practical results
636 from this invention which are revealed by the testimony.

Dr. Byrnes says that he has made some tests of the apparatus shown in Figure 1 of the patent in suit. I have seen this apparatus, marked "Defendant's Exhibit, Apparatus of Patent in Suit." It does not contain a cone mixer. It has a copper vessel of the same general shape indicated by the diagram Figure 1 of the patent in suit and it has a revolving cone, such as is indicated in Figure 1. It is not a cone mixer because it has no baffles for breaking up and mixing the fluid. Dr. Byrnes even calls it a "cone mixer." He apparently does not know a cone mixer. The cone mixer in 1905 was a well-known patented apparatus for mixing fluids and semi-fluids. It is disclosed in United States patent No. 444,345, issued January 6, 1891, to E. R. Gabbett, assignor of one-half to Boulton, Haywood & Boulton. This patent also says that patents have been obtained for this invention in Great Britain, Belgium and France. I have also seen the British patent No. 840 of 1889, and have read it and find that it does correspond with the United States patent, which I have also read. Messrs. Boulton, Haywood & Boulton were probably the surviving members of the well-known firm of Burt, Boulton & Haywood, to whom the British patent was issued jointly with E. R. (565—487) Gabbett, the inventor. As I have said before, I was familiar with this cone mixer before 1905. I was familiar with it in the form of cylindrical vessel having sta-
637 tionary baffles, although the Gabbett patents say that the vessel may be rectangular and the baffles would not then be necessary, or that the cone may have its direction of rotation "reversed after any desired intervals of time" (British patent, page 3, line 30, U. S. patent, page 2, lines 18, 19). If, therefore, the cone mixer in cylindrical form is to be used without baffles, it must have its direction of rotation reversed at desired intervals. If it is rotated continuously in one direction, you must have baffles that stand still while the cone rotates.

The cone mixer is diagrammatically shown in Figure 1 of the patent in suit and in the patent in suit it is particularly described as a "cone mixer" (Spec., page 1, line 84). It is also diagrammatically shown in the Cattermole patent No. 777,273, and there the cone mixers diagrammatically shown are merely described as "mixing vessels" (Cattermole, Spec., page 1, line 82). It is also diagrammatically shown, in Cattermole patent No. 763,259, issued June 21, 1904, and in Cattermole patent No. 763,260, also issued June 21, 1904, and in both these patents the cone mixers diagrammatically shown are described as "mixing vessels." These three prior patents give substantially the same diagrammatic indication of the well-known cone mixer as in Figure 1 of the patent in suit. The cone mixer is

shown in "Complainants' Exhibit, Young Advertisement A" in substantially the same way. The necessary baffles of (566—488) the
practical working apparatus are not specifically outlined in
638 the diagrammatic pictures. This advertisement in the journal
of the Society of Chemical Industry must have been seen by a large number of people, both in Great Britain and America, as this journal has a wide circulation in both these countries.

I have carried out an experiment with the apparatus illustrated by Figure 1 of the patent in suit, and I used for this purpose "Defendant's Exhibit, Apparatus of Patent in Suit," adding, of course, thereto the necessary baffles. 500 grams of defendant's ore, crushed in my presence to 80 mesh, were made into a pulp with 3200 cc. of water containing 5% of sulphuric acid. The temperature of the mixture was 35° centigrade (95° Fahrenheit). 0.75 cc. of oleic acid were added thereto, and the mixture was agitated for about ten minutes. It was then allowed to settle and showed a froth of about one and a half inches in depth. After re-agitation, the mixer was emptied out into the spitzkasten, which were filled with water having the same temperature as the mixture in the cone mixer. A froth appeared filling about the two first spitzkasten. It was collected on filters dried and weighed. Its weight was 107 grams. The tailings recovered from the spitzkasten, looked clean. It is unfortunate that the whole of the Gabbett apparatus cannot be completely emptied out. The residue contained therein, which had the appearance something like the original ore, weighed 136 grams. To collect this residue, it was necessary to pour water into the Gabbett and tilt the Babbett over
and let it run into (567—489) another basin, and to wash
639 with the wash bottle the Gabbett out. Naturally the froth
was broken up, and sunk in this operation and mixed with the tailings, and the impression from superficial observation was that the color resembled the color of the ore. If the apparatus were used as it is intended for continuous work, such residue would not result because there would be continuous addition of new pulp and the residue would be treated with the new pulp. There could only be in a day's work one residue left, which would not appreciably influence the result of the recovery. As a matter of fact, it would have no influence, as it would be treated the next day.

An assay of the 107 grams recovered showed the presence of 49.5% of zinc.

The quantity of zinc contained in the 107 grams of concentrates recovered as described in the previous experiment in the apparatus marked "Defendant's Exhibit, Apparatus of Patent in Suit," was 52.9 grams. The 500 grams of ore used in this experiment contained 18.5 per cent of zinc; that is, 92.5 grams. The recovery, therefore, would be 57.6%. I have, however, explained that 136 grams remained in the cone mixer, as they could not be run into the spitzkasten. The zinc content of these 136 grams was 15.1% of zinc, or 20.5 grams, and these 20.5 grams have to be deducted from the zinc content of the ore submitted originally to the treatment by the process of the patent in suit. The zinc content of the 500 grams of ore was

92.5 grams, which, after the deduction of the 20.5 grams of
640 zinc remaining in the cone mixer, leaves a zinc content (568—490) of 72 grams in the ore, in which an actual recovery was obtained, and this recovery was 52.9 grams or 73.5%. The tailings weighed 245 grams and contained 5.3% of zinc, that is, 13 grams.

I used 500 grams of ore originally. I recovered as

Concentrates	107	grams
Residue in cone mixer	136	"
Tailings	245	"
	488	grams.

I, therefore, lost in this operation 12 grams or 2.4% of ore. The zinc content of the ore was 92.5 grams. I found in the

Concentrates	52.9	grams
Residue in cone mixer	20.5	"
Tailings	13	
	86.4	grams

I lost, therefore, 6.1 grams of zinc, equal to 6.6% of zinc. This loss is easily accounted for by a permissible error in the different assays and by the loss of the 12 grams of ore in the operations. The 12 grams of ore represent the zinc content of 2.2 grams of zinc.

I have frequently made experiments with this apparatus and I have never failed to produce a froth on the spitzkasten. The froths varied in size and covered sometimes only one spitzkasten, sometimes
two, sometimes nearly two, of the apparatus marked "De-
641 fendant's Exhibit, Apparatus of Patent in Suit." I attribute these variations to the imperfect arrangement in the tap of the outlet pipe of this apparatus. This outlet pipe is provided with a globe valve, that is, a valve in which the water (569—491) flows first upward, then downward, and then again upward, when the tap is unscrewed; the gangue has time to settle and prevents the flow of the mixture contained in the cone mixer. This occurred in every experiment which I made with this apparatus and the passage of the mixture contained in the cone mixer had to be started by vigorous suction. The valve ought to have been a gate valve, which forms, when the tap is unscrewed, a straight line with the two connecting pipes. But even in spite of this unsuitable valve, the recovery was always obtained as a froth.

I gather from the cross-examination of some of the witnesses, that the defendant contends that a froth is not always formed, but that the recovery is sometimes the result of skin flotation. That is not so; it is always a froth. I have tested this in every experiment I made with the apparatus marked "Defendant's Exhibit, Apparatus of Patent in Suit." In every experiment I made, I allowed the mixture first to settle in the cone mixer after agitation, and in every instance a heavy froth separated. Mr. Sulman suggests the pos-

sibility that the force of surface tension of a large bare water surface might cause the expanding of the froth and change it into skin flotation. I have seen the ends of a froth, when a large, free
642 water surface was left, stretch out and present the appearance of skin flotation. But on close examination, air bubbles densely covered with minerals were seen. But, even if the froth should stretch or expand under abnormal conditions into skin flotation on being exposed to the force of a large bare surface of water, either in the beginning of (570—492) the daily work or perhaps owing to a breakdown of the machinery, surely that has nothing to do with the real question, namely, that the result of the agitation in complainants' process is the formation of a froth. This froth results always from complainants' process. It is immaterial whether it is collected after its formation either as froth or as skin flotation, or whether it is sunk in the tank and destroyed and collected as finely divided minerals. Any form of collection may be used which prevents its remixing with the tailings. The real invention contained in complainants' patent in suit is the separation of minerals from ore as a froth by agitating a mixture of pulp and oil in such manner that air is beaten in and that, after allowing the mixture to settle after the agitation, a froth carrying the oiled minerals forms on the surface of the water.

I have said before that the apparatus, Figure 1 of the patent in suit, is intended for continuous work, and it is stated, page 2, line 53, that there may be any number of cone mixers in series. The number of cone mixers to be used, it is self-evident, would be such as to make the best use of the spitzkasten, to keep them completely covered with the froth so as to prevent the breaking of the
643 froth, and to keep the circuit in continuous activity. I notice that Dr. Byrnes describing experiments with the apparatus offered in evidence and marked "Defendant's Exhibit, Apparatus of Patent in Suit," does not mention that he experienced any difficulty in emptying the cone mixer (571—493) through the valve with which it is provided, into the spitzkasten. I can only repeat what I have said before, that I had to apply suction in every experiment I made. He also succeeded in fully emptying the cone mixer into the spitzkasten, in which operation I failed. He says:

"The cone being maintained in motion, wash-water was added to remove the residue, and the vessel was slightly tilted to empty out the portion contained in the concave bottom."

I cannot conceive how the cone mixer could be tilted up whilst the agitator was running and running at 1600 revolutions a minute. I know of no way how this can be done. Furthermore, the operation of pouring in water from a height on a froth might easily result in the mineral being sunk and removed from the sphere of concentration. But the chief objection to this experiment is, that Dr. Byrnes did not carry out the instructions of the patent to introduce air into the mixture of pulp and oil by agitation to form the froth. The cone mixer used was without baffles, that is, without the element necessary for the introduction of air into a liquid, and the necessity of the presence of baffles would be obvious to any

metallurgist, whether he knew of the apparatus or not. The
644 patent clearly says that the agitation must introduce air, and Dr. Byrnes might have readily used one of a number of apparatuses of which he says later on in his summary that they could have been used for such purpose according to his experiments, and one of which had been described for introducing air into a liquid by agitation to effect a chemical action, namely, oxidation, in the process of the (572—494) gold recovery by means of cyanide solutions (Stoveken Patent No. 729,805). Dr. Byrnes used the cone mixer without baffles and he succeeded, even with this defective apparatus, to produce some froth. He says:

"Some froth floated down the shallow trough and over the bond of the water contained in the spitzkasten, passing on into the launder and being collected and filtered."

Dr. Byrnes continues as follows:

"Considerable mineral, in the form of fine individual oiled particles, also floated down on the surface of the water, as a mere film supported by surface tension."

This shows clearly that there was an insufficiency of air to produce a froth, but that some air was introduced which effected skin flotation, if Dr. Byrnes was right in his observation that what he saw was skin flotation and not an expanded froth including fine air bubbles covered densely with minerals such as I have seen to occur some times in this apparatus.

Dr. Byrnes used in this experiment .135% of oil of the amount of ore treated. That is a quantity near enough to the quan-
645 tity found by the patentees as "suitable and economical," a statement which Dr. Byrnes has apparently forgotten, although it forms the keystone to the ordinary working of the process. He says that the patent "in the specific 'example' simply specifies 'a very small proportion of oleic acid (say, from 0.02 per cent to 0.5 per cent on the weight of ore),' a very wide range, with no statement or indication as to whether the 0.02 per cent is preferable or the higher limit, twenty-five times as much, or what conditions are to determine the amount to be used."

As I said, he has forgotten the important statement on page 1, line 96, of the patent in suit: (573—495)

"The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1 per cent of the ore; but this proportion has been found suitable and economical."

And the complaint which Dr. Byrnes made is not justified by fact.

Dr. Byrnes states:

"From my study of the prior art, and from my tests of the processes disclosed therein, as well as of the process in suit, I am entirely unable to find any point of novelty in the process described and claimed in the patent in suit, so far as it is carried out by the use of the apparatus shown in Figure 1."

646 As Dr. Byrnes has given a summary of the essence, at least as he tries to interpret it, of the prior art, I will criticize that

part of the above statement which refers to the prior art when I am considering this summary. But he limits his conclusions in this statement to the use of the apparatus shown in Figure 1. He has not used the apparatus described in the patent in suit and diagrammatically illustrated by Figure 1. He omitted that part of it which is essential to the process of the patent in suit. The patent tells you to agitate for the purpose of beating in air. That he has not done and his conclusions as drawn from the working of Figure 1 of the patent in suit are faulty.

Dr. Byrnes states that the patent in suit is very vague as to the details of the process and as to the proportions of oil and acid to be employed. He says here again that the patent specifies the proportion of oil and acid, "say from 0.02 per cent to 0.5 per cent on the weight of the ore," (574—496) and continues later on—

"Later the description states, in the most general terms, that the proportion may be 'under 0.1 per cent of the ore.' "

He omits deliberately to state the end of the sentence, closing the quoted part from the patent in suit (page 1, lines 100, 101): "may be under 0.1 per cent of the ore; but this proportion has been found suitable and economical."

647 This is a distinct statement and sufficient guidance for any metallurgist to work upon. It is impossible to be more accurate in a process which may be used for a large number and variety of different ores, and it is impossible to demand of a patentee that, for the purpose of his patent specification, he should try to collect all ores from the different parts of the world and describe a specific treatment for each of them, with specific proportions of all the ingredients for each of them. They give as an example the well-known Broken Hill ore, with which they appear to have been very familiar. They inform the world what they consider the limits of their proportions, and they add that in their experience 0.1 per cent of oil of the amount of ore has been found "suitable and economical." Surely one cannot demand more, and even a metallurgist of very low qualifications cannot fail to determine with the greatest ease what quantities will give him the desired results. Dr. Byrnes then states that the amount of sulphuric acid or other acid or salt to be added may be any fraction under one per cent or up to one per cent. This statement is again not a full statement of what is contained (575—497) in the patent, because the patent says that the water should contain a fraction of one per cent or up to one per cent of a mineral acid or acid salt. I cannot find any reference to a salt, only acid salt. The reason for the addition of acid is stated plainly on page 1, lines 41-44: "to prevent gangue

648 from being coated with oily substances, or, in other words, to render the selective action of the oil more marked."

It is well known to any metallurgist, and it must have been well known to Dr. Byrnes that ores frequently contain small quantities of substances which absorb mineral acid and that therefore it was impossible for the patentees to fit all varieties of ore which are in existence with one coat. The object of the patentee is to have an acid re-action; that means, the faintest quantity of acid present during

the process of oiling, and as long as a test paper, after having been wetted with the pulp, shows acid reaction, the condition of the patent is fulfilled. These are such simple tests that, if a student after a few months' study was not capable to carry them out, he was sure to be severely censured. It is the easiest thing to find within five or ten minutes the quantity of acid which will answer the purpose of the patentees. Dr. Byrnes has a very low appreciation of the abilities of metallurgists.

As to the suitability of the different oily substances for the separation of minerals from ore, different types of oil and different oils of these different types have been frequently described prior to the application for the patent in suit, and were well known to people conversant (576—498) with the art. Dr. Byrnes apparently expects, at least that is the only conclusion I can come to from these remarks, that the patentees ought to have tried every oil in existence with every ore in existence and ascertained for every
649 ore in existence the quantity of sulphuric acid which will leave faint acidity during the operation of the process of the patent in suit. Such a patent would fill a fairly large volume. Of course, the suggestion that every oil should have been tried by the patentees is absurd. The patentees give a fair warning, page 1, lines 61-69:

"The proportion of mineral which floats in the form of froth varies considerably with different ores and with different oily substances, and before utilizing the facts above mentioned in the concentration of any particular ore, a simple preliminary test is necessary to determine which oily substance yields the proportion of froth or scum desired."

And the patentees describe specifically the use of oleic acid, thereby indicating which of the oily substances they found efficient. The number of oils which may be used is very large, and all that can be demanded of a patentee is to explain how one can determine by a single test which of a large number of substances suitable for the purpose of a patent is the most suitable and economical. It is, of course, essential that the patentee should state which substance he found in his experiments the best, and the patentees of the patent in suit have done so.

Dr. Byrnes then complains that the agitator or mixing vessel shown is confessedly old with Cattermole and is relatively inefficient. The patent in suit does not claim any novelty for this apparatus. But I deny that this apparatus is inefficient, and
650 I say it is only inefficient (577—499) as used by Dr. Byrnes with parts of the apparatus omitted. If properly used it is an excellent apparatus for the purpose of the patent, and it was also an excellent apparatus for the Cattermole process. The froth-separating apparatus I agree with Dr. Byrnes is, as shown in Figure 1, a very old device and I need not add that it is not claimed as a novelty in the patent in suit.

As to Dr. Byrnes' conclusion, I disagree with him, particularly with his statement that the patent in suit describes and claims no new process. In my opinion, the process disclosed in the patent and

set out in the claims is a fundamentally new process, which involves a hitherto unknown phenomenon. I shall sum up the prior art later in my deposition.

I inquired, after having read the testimony, and the description of Froment, for the apparatus which had been sent by Froment at the end of 1903, but I was informed that this apparatus had been destroyed long ago, as it had proved of no value and quite inefficient. I had, therefore, an apparatus constructed after consultation with the metallurgist of Minerals Separation, Ltd., Mr. A. Howard Higgins, who had used the apparatus. I did not have the whole of the apparatus made for the obvious reason that the screens had nothing to do with the question in issue. I had made the mixer and the vat with the coil. This apparatus is "Complainants' Exhibit, Reproduction of Froment Mixer" and "Complainants' Exhibit, Reproduction of Vat with Coil."

651 I performed yesterday, together with Prof. Chandler, (578—500) who has been ill and who was only the first time capable to leave his house after his protracted illness, in the presence of counsel for complainants, the following experiments:

1. The ore which has been deslimed by Mr. Higgins was not quite dry. We, therefore, first analyzed what amount of moisture was left in it. We found it contained 15% of water. We took a quantity of ore corresponding to 2½ kilos of dry ore and filled it into the Froment mixture. I should mention that the ore was Broken Hill ore. We then added 6 liters of water and 62½ grams of engine oil and agitated the mixture at a speed as near as possible of 300 revolutions per minute. I say as near as possible, because as this apparatus shows it is worked by hand and it is impossible to say for certain whether the speed was always the same. It might have been at times greater and at times perhaps slower. 50 grams of calcite had been added. The agitation lasted about fourteen minutes, but after ten minutes the agitation was stopped and the mixture examined. There was a thin film of oil on the top, extremely thin, and there was some air bubbles in it. The oiled ore was at the bottom of the mixer. It was examined also before it was emptied out and the same appearance was observed, namely, a thin film of oil with some air bubbles on the surface of the liquid and the oiled ore at the bottom. The mixture was then, whilst being

652 agitated, emptied out into the vat provided with the coil, but only water ran out and the ore had to be washed out with water. When everything was contained in the vat provided with the coil, (579—501) the rake contained therein was turned around at a speed of about ten to twelve revolutions per minute, and 143 cc. of diluted sulphuric acid, containing 35% of sulphuric acid, was poured in through the leaden pipe which ends in one of the perforated coils at the bottom of the vat. But no appreciable amount of minerals were carried to the top. I should say, scarcely any appeared. Although the depth of the ore was such in the vat with the coil that the rake worked in it, the construction of the rake in my view is wrong and the rake is inefficient for the purpose it is intended for. It cuts grooves into the ore pulp and moves in the same

grooves after they have once formed. The experiment proved only two facts: that the oil settles both in the mixer if the agitation is stopped and in the vat with the coil at the bottom, and that the only thing which appeared on the surface of the mixture is a thin film of oil.

I arrived at the conclusion that neither the construction of the agitator contained in the mixer is suitable and efficient, nor the construction of the rake contained in the vat with the coil. I therefore, made an experiment, as follows:

2. A quantity of the deslimed ore, corresponding to 500 grams of dry ore, was filled into a cone mixer, 1200 cc. of water, 12½ grams (14 cc.) of engine oil, and 10 grams of calcite were
653 added, and the mixture was agitated in the cone mixer for ten minutes at a speed of 300 revolutions per minute. After ten minutes' agitation, the apparatus was stopped and the mixture examined. There was, just as in the Froment mixer, a thin film of oil on the (580—502) surface of the liquid. The oiled ore was at the bottom. The mixture was again agitated and, whilst being agitated, run out into a wide shallow vessel. The oiled ore was, as before, at the bottom of the vessel; a film of oil, but no minerals on the surface of the liquid. The mixture was gently stirred by hand with a spatula and 30 cc. of dilute sulphuric acid containing 35% of sulphuric acid gradually added to it. A layer of oil with concentrates appeared on the surface. It was removed and further 30 cc. of the same acid added, the result being that more minerals appeared on the surface having the look of a magma; that is, of a pasty mass of oil and minerals enclosing some carbonic acid bubbles. The concentrates thus obtained looked very good, but the tailings were not quite clean. If the minerals and oil were allowed to remain on the surface, that is, not collected, they fell again to the bottom after a short time. As I stated, I worked at a speed of about 300 revolutions in the cone mixer. This speed is given in the instructions obtained from Froment as a proper speed. But as it is a speed for a larger vessel, I thought it fair to repeat the experiment with a much greater speed.

3. A quantity of the deslimed ore corresponding to 500 grams of dry ore (Broken Hill ore) was filled into a slide machine,
654 1200 cc. of water, 14 cc. of engine oil (12.5 grams, equal to 2½% on the ore), and 10 grams of calcite were added thereto and the mixture was agitated in the slide machine at a speed of 1600 revolutions per minute. (581—503) The agitation was stopped after two minutes. A film of oil was on the surface of the liquid. The oiled ore was at the bottom. The result was identical with the result obtained either in the cone mixer or in the Froment mixer. The mixture was then slowly agitated at about twelve turns per minute. This was, of course, done by hand, that is, by moving the belt driving the agitator by hand, whilst, at the same time, 30 cc. of dilute sulphuric acid (containing 35% of sulphuric acid) was gradually added. The concentrate rose in the form of a magma to the top. It was removed and had the appearance of a very good concentrate.

In these experiments I went out of my way to give the Fromen instructions the best chance of success, and, as is seen from the de scription of my experiments, I used apparatus in experiment which was not available at the date when the Froment instruction were received. These experiments confirm that the process revealed by the Froment instructions can be carried on in a laboratory fo the concentration of ore, but is of no use for an economical con centration to-day nor was it at the time when these instruction were received.

The ore which I used in these experiments was, as is stated Broken Hill ore. It contained 17% of zinc and 6% of lead.

655 The instructions of Froment direct the use of mineral en gine oil. I used in these experiments mineral engine oil of the best quality known as Mobiloil, and which is a mineral oil. The instructions as to the quantities of oil to be used are as follows:

"If the ore contains more than five per cent of metallic matter such as copper, lead, it will be (582—504) necessary to add a little more oil. As a general rule, one may assume:

1% of oil for ore containing up to 5% of metals; 1½% of oil for ore containing up to 10% of metals; 2% of oil for ore containing up to 15% of metals."

As this ore contained 23% of metal, I used 2½% of the oil, which was also in the proportion of 50 lbs. of oil to the short ton of ore.

I performed the tests with Dr. Chandler which I had made be fore as the test tube reproductions of Dr. Byrnes' alleged Fromen experiments in the slide machine. The results were exactly the same as I have described before. They did not produce the Fromen result described in the patent, and did not produce any separation of the values from the gangue.

Dr. Byrnes makes his summary of the prior art under different headings. He first enumerates the patents in which he finds the disclosure of the preferential affinity of oils and fats for the metalliferous constituents of ore or for graphite. Then he enumerates the documents in which he finds a disclosure of the use of

656 acid. Then he enumerates the documents in which the flotation of oiled minerals by attachment thereto of bubbles of air or gas is disclosed. Then he enumerates the agitators, which according to his tests may be used for entangling atmospheric air and beating it through a mixture. Then he states that widely different amounts of the same oiling agent have been used and finally he enumerates the patents in which heating of the oil or of the mixture of pulp and oil has been described. Dr. Byrnes' mode of making this summary of the prior art is very misleading and it is not a summary which (583—505) can be used as a guidance to ascertain the true state of the art and what is revealed therein. It may be called an index of the contents of the different documents, but it is not a revelation of the processes used therein and of the facts produced thereby. An invention is not anticipated because some of the steps have been used before it was made to produce different results. If that were so, the progress of the world would be arrested and further inventions would be impossible. There are

innumerable chemical inventions which use the same chemical substances, which use the same steps in producing a new result. I will give an illustration of what I mean. If you treat, for instance, napthol with a sulphuric acid at 70° Centigrade, a new compound, a combination of napthol and sulphuric acid, is obtained. If the same napthol is treated with sulphuric acid at 20° Centigrade, the result again is a combination of the napthol with the sul-
657 phuric acid. The latter compound, when submitted to certain chemical reactions, produces one of the most beautiful red colors in existence. The former compound does not yield, under the identical treatment, any color whatever. Another example of the variety of action is shown in cotton. If cotton be acted upon by dilute sulphuric acid containing as little as .025% of sulphuric acid, it is tender. If cotton is treated with dilute sulphuric acid containing about 50% of sulphuric acid, it is rendered white and lustrous, it is what is popularly called mercerized, and stronger than it was originally. The novelty in a patented invention is not destroyed because one or two steps had been known before. (584—506) The novelty depends on the process as a whole and on the novelty of the result produced, and it does not matter whether any of the steps or all of them had been used before for different purposes, and it does not matter whether some of them had been used in earlier attempts to achieve a similar object and had failed. That rather increases the value of the invention, because the former failures were a warning against renewed attempts.

Dr. Byrnes' first point is that he finds a clear disclosure of the preferential affinity of oils and fats for the metalliferous constituents of ore in several enumerated patents. As the patentees admit this in their specification of the patent in suit and specifically refer to two of the patents which Dr. Byrnes enumerates, to wit, Cattermole, No. 777,273, and No. 777,274 (Spec., page 1,
658 lines 16-27), Dr. Byrnes is merely stating what the patentees admit.

Dr. Byrnes' second point is that he finds a clear disclosure of the use of acid, for example, sulphuric acid, including small amounts of acid, in processes of oiling the metalliferous constituents of ore, with statements that acid increases the preferential affinity of oil for the metalliferous constituents, in certain enumerated patents. This is undoubtedly true and no point of novelty is made as to this in the specification of the patent in suit, and the same two patents which Dr. Byrnes includes under this point are specifically referred to in the patent in suit as above stated. As I have said, this was the invention of Carrie Everson. (585—507)

Dr. Byrnes' third point is that the flotation of oiled minerals by the attachment thereto of films or bubbles of air or gas or by the adhesion of the oiled particles to bubbles of air or gas is disclosed in certain prior patents, which he enumerates. That is true of some of them, but it is not true of the Schwarz, Kirby and Froment patents. In these documents it is oil which includes minerals and gas bubbles and this mixture is floated.

Under this point he also says that he can use agitators of prior

patents for the purpose of the patent in suit. Now, that he ha
learned of the invention, this may be true. Probably there are
great many more agitators in existence which can be used for th
purpose of the process of the patent in suit, but the important fac
is that none of them was used for that purpose. His refer
659 ence to the Everson patent is altogether wrong. Everson de
scribes no agitator at all, but only agitation sufficient to caus
the mixture of mineral, oil and acid, with oil in very considerable
quantities, the oil and mineral being removed by a constant overflow
well known at the time, and the operation being possible because the
oil and mineral are lighter than the sand or gangue. None of the
patents mentioned depends for its success on the beating in of air
by means of an agitator. In some of the documents mentioned such
agitation which would result in the beating in of air would be im-
possible; in others it would prevent the achievement of the result.
I cannot pass over this paragraph without comment on the remarks
which Dr. Byrnes makes about the Froment test tube examples. I
utterly disagree (586—508) with the following statement:

"In Froment's test-tube experiment, agitation sufficient to coat
the mineral particles with a thin film of the oiling agent also
thoroughly aerates the mixture, the fine bubbles of air distributed
throughout it, and attaching themselves to the oiled particles, acting
with the chemically evolved gas to float them."

There is not a word mentioned in the Froment patent about
aeration by atmospheric air and I further say that such aeration is
utterly impossible according to the description which Froment gives
of his test-tube examples.

Dr. Byrnes' fourth point that widely different amounts of the
same oiling agent have been used is true, but it is not true
660 that oils have been used under 1 per cent or a fraction of
1 per cent of the weight of ore, as stated by Dr. Byrnes. It is
certainly not true that the phenomenon of the patent in suit, namely,
the agitation froth, has either been produced with large or with
small quantities of oil. The only document which discloses com-
paratively small quantities of oil, namely 4 to 6 per cent on the
minerals, is Cattermole, and he does it for the definite purpose of
increasing the falling power of the minerals in order to be able to
collect them at the bottom of the classifier.

Dr. Byrnes' fifth point is that the use of warm water or a warm
mixture is an obvious and necessary expedient where oleic acid is
used. That is not only not obvious but quite unnecessary for the
purpose of oiling, as ordinary commercial oleic acid is a liquid at
normal temperatures. The red oil used by defendant is an impure
oleic acid, and, therefore, not as liquid as ordinary commercial
(587—509) oleic acid. According to my opinion, the increase of
temperature plays a different part from that which Dr. Byrnes tries
to explain at such length. It is a well-known physical fact that the
power of occluding gases, that means, the power of attracting gases,
increases with the increase of temperature with metals, and the
superior results which are obtained at the higher temperature I
attribute to this well-known physical fact.

From Dr. Byrnes' summary nobody can gather any information whether any of the alleged anticipation describes the process and the result, either identical or similar to the process or result of the patent in-suit. Dr. Byrnes' summary is not a summary, but an index.

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As to the statements made by Dr. Byrnes relative to what appears in the file record of patent No. 788,247 of Cattermole, Sulman and Picard, this statement of Dr. Byrnes is again a proof of the difficulty present in the minds of certain people that they cannot put themselves back to and form a correct opinion of the knowledge of an earlier time. They interpret always by the later standard. But even with this explanation, this answer of Dr. Byrnes is very surprising. An unbiased mind reading these two documents, namely, patents Nos. 777,274 and 788,247, which have been correctly called the soap patents, would know at once that they are intended for the use of the same quantity of oil as has been revealed in the Cattermole patent, No. 777,273, and that they use, instead of oil, soap, and produce the oil therefrom, as the patentees call it, in situ, which means in the mixture, by the addition of acid. No. 777,274 (588—510) describes the recovery of the concentrates by granulation. No. 788,247 describes the recovery of the oiled particles by skin flotation and refers to any of the well-known methods for producing the effect of skin flotation. The expression, "only seek to coat every particle of metalliferous matter as thinly and evenly as possible," occurring in an argument filed by the applicants for their patent No. 788,247, surely is quite clear and is only capable of one interpretation, namely, that the object of the patentees was to coat every particle of metalliferous matter as thinly and evenly as possible, as was known at the time, and that was with the quantity of oil used by Cattermole, and disclosed in patent No. 777,273, the difference being that, in the latter document, the oil was present as such in the mixture whilst in the former the oil was generated from soap. I will quote the paragraph of the argument in which the above-quoted sentence appears:

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"A very important line of distinction between Everson's process and the applicants' is that Everson oils the whole of the ore and gangue initially as thoroughly as possible and seeks to wash the gangue out of the mass by acid water or the like. The applicants on the other hand avoid any oiling of the gangue by wetting the whole first with water and by such preferential wetting and the mode of producing the oleic acid only the metalliferous matter present is coated. The applicants never make a pasty mass of the whole ore, but only seek to coat every particle of metalliferous matter as thinly and evenly as possible and therefore to keep the gangue and the mineral particles from agglomerating together."

The argument was used to differentiate the process from Everson's earlier invention described in patent No. 348,157. Everson mixed the ore with oil first. In order to do this, (589—511) she had to use considerable quantities of oil. When the mixture of

663 oil and ore was then treated with water and acid, the gangue was cut out and there was a large quantity of oil in excess in which the oiled mineral particles were embedded. In the process used in patent No. 788,247, the oiling of the gangue did not occur, and therefore there was no excess of oil present in which the oiled particles would unite together. The coating with oil can only of course refer to the coating with such quantities as were known at the time, and the lowest quantities used known at the time were the quantities of Cattermol-. Everson used for making the paste 18% of oil of the amount of ore to be treated. It is in evidence that the Cattermole process was tried mainly for Broken Hill ore, which contains about 25% of minerals. Cattermole, Sulman and Picard only oiled the values and not the gangue, and they would require only 6% of oil if they were to produce the same effect as Everson did with 18% of oil. As a matter of fact, Cattermole found 4 to 6 per cent of oil a suitable quantity in proportion to the mineral in the ore, or 1.4 to 2 per cent of oil in proportion to the ore with which they mainly experimented. I repeat that this statement, coated as thinly as possible, can only refer to the coating of minerals as was known at the time and not to the coating of minerals which was discovered long after, and disclosed in the patent in suit.

There is a wide difference between the coating with oil as disclosed in patents No. 788,247 and No. 777,274, and the coating with oil as disclosed in the patent in (590—512) suit, and it is

664 quite apparent from the quantities which are described as useful in the two different sets of patents. In the Cattermole patents No. 788,247 and No. 777,247, the quantity is clearly alike with the quantity disclosed in Cattermole patent No. 777,273, and that is 4 to 6 per cent on the minerals (1.4 to 2 per cent on the ore), with a warning that the process is not to be used with lean ores. In the patent in suit the quantity found suitable is .1 per cent. Expressed in pounds per short ton, Cattermole requires 28 to 40 lbs. as a useful quantity, and the patent in suit describes 2 lbs. as a useful quantity. Furthermore, it is a necessity for the Cattermole invention that the oiled particles can be granulated and rendered specifically heavy, heavier than the gangue. In other words, they must have a greater falling power than the gangue, so much greater that the gangue can be removed by an upcast, or an upward flow of water, whilst the granules are not removed thereby. The Cattermole granules have an oily look, no luster, no light is reflected therefrom. The oiled particles of the patent in suit appears as a froth on the surface of the liquid. They are brilliant, metallic looking substances, no oil can be discerned on them, and it is impossible to obtain granulation from them. There is no overlapping possible in these two patents. Cattermole warns you against the use of lean ore. If you want to treat lean ore, add granules to it, which have already been formed, or other matter having affinity for oil, or pulverized mineral matter which had been obtained from an ore. It is clear that he has in his mind

as a suitable (591—513) ore for his treatment Broken Hill
665 ore. The patent in suit discloses as a suitable and economical amount .1 per cent of oil. It is true that the patentees do not limit themselves to this quantity, but that is the quantity, which, on careful reading of the specification, would suggest itself to a metallurgist.

I disagree with Dr. Byrnes' classification of what he calls oil-gas flotation processes. I say that the Everson process depends on the reduction of the specific gravity of the minerals by oil and the sinking of the minerals is prevented by an upcast. Glogner and Good are oil buoyancy flotation. Patent No. 788,247, a soap patent, results in skin flotation, and the same is true of No. 793,808 to Sulman and Picard. Patents No. 807,501 and No. 807,503 to Schwarz depend on oil buoyancy flotation assisted by gas, and the same is true of No. 809,959 and No. 876,626 to Kirby. British letters patent No. 12,778 of 1902 to Froment depends on oil flotation assisted by gas produced in a nascent state.

I disagree absolutely with the long argument in which Dr. Byrnes tries to show that Cattermole is an oil-gas flotation process. Cattermole does not disclose anything but the formation of heavy granules, so heavy that they remain at the bottom of the liquid even after the introduction of an up-current of sufficient force to carry the gangue away.

It is again an attempt to alter the character of an earlier invention by the introduction of later processes and later investigations. It is
particularly unfortunate (592—514) and uncalled for with
666 the Cattermole patent, which is a brilliant invention, clearly written and well defined both as to process and to result.

I will now give a summary of the patents referred to in the deposition of Dr. Byrnes. These patents may be roughly divided into three classes, namely:

1. Apparatus.
2. Processes for ore treatment by means of water.
3. Processes for ore treatment by means of oil.

Apparatus.

The patents disclosing the invention of apparatus and the literature quoted as disclosing an apparatus are:

Wagner No. 373,113;

Stoveken, No. 729,805;

Extract from Treatise on Chemistry Applied to Manufacture of Soap and Candles.

Wagner discloses a churn by which he alleges he can produce lactic acid by the action of the oxygen of air on sugar. It has been introduced apparently for the purpose to show that it was known that air could be introduced into a mixture by agitation, and that a chemical action could be produced thereby, and that in this way casein could be coagulated and separated from the butter when the butter globules are ruptured by agitation. Such an apparatus would not stand up under the severe conditions of agitating a gritty ore pulp.

Stoveken describes an apparatus for the extraction of precious metals, and more especially gold, from ores of low grade. It
667 is an agitator destined to bring air into (593—513) the mixing of the ore with a weak cyanide solution, in order to effect a rapid and complete solution of the gold and silver contained in the ore by providing the oxygen necessary for the chemical action. It has no reference whatever to the concentration of ores by means of oil.

The Extract from the Treatise on Chemistry Applied to the Manufacture of Soap and Candles has no reference to ore concentration. It is intended to fill a liquid soap with air bubbles so that its specific gravity is reduced, and that it can float on water.

I submit that there is nothing disclosed in these documents which could shed any light on ore concentration by means of oil, and I further submit that there is nothing contained in these documents disclosing the process of the patent in suit.

2. *Processes for Ore Treatment by Means of Water.*

The following patents fall under this heading:

Bradford	No. 345,951;
Hockley	" 466,753;
Rouse	" 469,599;
Hebron & Everson	" 471,174;
Delprat	" 735,071;
Delprat	" 768,035;
Potter	" 776,145.

Bradford's invention consists in processes for saving materials floating on water and to collect losses occurring on Rittinger tables, Frue vanners and jigs. An ore, when immersed in water, will produce with part of the (594—516) minerals skin flotation,
668 and Bradford's invention was to collect these minerals floating as skin flotation. There is no oil used whatever and the economy which is effected is due to the well-known phenomenon of skin flotation, and no slimes can be treated with it.

Hockley discloses an apparatus to save the float mineral, usually called slimes and sometimes flour gold and silver, by surface tension flotation. He assists to produce this flotation by means of an up-current, which may be air, water or steam. When the particles arrive on the surface, they will float on exposure to air. It is a simple surface tension phenomenon and no oil is used to produce it.

Rouse discloses a process for the saving of slimes from water used in grinding ores. This water contains sometimes valuable minerals and Rouse saves it by bubbling air into the water. The principle is the same as in Hockley. He uses an up-current rapid enough to prevent the descent of the slime water. He does not use oil.

Hebron and Everson disclose an attempt to reduce the specific gravity of minerals by attaching to them substances of much lower specific gravity. It is not quite clear whether the patentees thought

that their flotation was due to specific gravity. The process, in my opinion, is a surface tension flotation process. No oil is used.

Delprat in his two specifications describes the carrying of minerals to the surface of water by means of gas bubbles generated in the mixture. The gas bubbles attach themselves to the mineral
669 and lift it to the surface. No. (595—517) oil is used.

Potter is like Delprat, a flotation of minerals by gas bubbles generated in the mixture, no oil being used.

3. *Processes for Ore Treatment by Means of Oil.*

Under this heading I shall treat the patents in four subheadings, as follows:

(*a*) Oil and ore mixed, and mixture treated with acidulated water;

(*b*) Pulp treated with oil; concentrates separated from surface;

(*c*) Pulp treated with oil; concentrates separated from bottom of liquid;

(*d*) Pulp treated with oil; concentrates floated by introduction of gases through pipes or generation of gases in the mixture.

Under the subheading (*a*) I include the following patents:

Everson ..... No. 348,157;
Schwarz ..... " 807,501;
Schwarz ..... " 807,503.

Under the subheading (*b*) I include the following patents:

Elmore ..... No. 676,679;
Elmore ..... " 689,070;
Glogner ..... " 736,381;
Good ..... " 745,960;
Kendall ..... " 771,075.

670 Under the subheading (*c*) I include the following (596—516) patents:

Cattermole ..... No. 777,273;
Cattermole, Sulman & Picard ..... " 777,274.

Under the subheading (*d*) I include the following patents:

Froment ..... No. 12,778 of 1902;
Sulman & Picard ..... " 793,808;
Cattermole, Sulman & Picard ..... " 788,247;
Kirby ..... " 809,959;
Kirby ..... " 838,626.

(*a*) Oil and ore mixed and mixture treated with acidulated water.

Everson discloses two processes in her patent. According to the first, she produces a stiff mass by mixing the ore with a compound

prepared by mixing a small qauntity of sulphuric acid with cotton-seed oil. The dough-like mass is then kneaded in water, by which operation the gangue is removed. It is not a practical process and has never been used. The quantity of oil which she advises is in proportion of about 6 grams of oil to 112 grams of ore (over 5 per cent) which is 100 lbs. of oil to the ton of ore, and which is altogether prohibitive.

Everson's second process depends on the reduction of the specific gravity of the ore by such quantities of oil and to such an extent that the mixture of mineral, and oil is lighter than the gangue, and on the separation of such a mixture of mineral and oil by an up-current of water. She mixes the pulp with a quantity of oil
671 amounting to 18% of the ore, or 360 lbs. of oil to the ton of ore. The (597—519) process is out of question on account of its high cost, even if the process would work. No froth is produced and no satisfactory separation of values from the gangue can be obtained by this process according to my experiments made in strict accordance with this Everson patent.

Of the Schwarz patents, the first one states as the object of the invention the conversion of valuable oxides or carbonates into sulphides and adds the description of an oil separation process for the recovery of sulphides thus obtained by means of oil. The separation process of sulphide minerals from the gangue is more fully described in the second patent. Schwarz makes first a paste of his ore and oil (the oil is a mixture of two different oils in certain quantities, which at ordinary temperature is solid), and then blows air or gas through pipes into this paste. To be able to do this, he must at least use a quantity of 50% of oil, or 1,000 lbs. to the ton of ore; otherwise, he could not blow the air in and keep the mixture of ore and oil in the vessel. Such a paste is pretty thick and he could only use slow agitation with it. He then mixes water with it and continues the blowing in through pipes of air or gas to assist in the distribution of the water throughout the paste and to effect the thorough washing out of the tailings. Schwarz's recovery is due to oil buoyancy flotation assisted by the enclosure of air bubbles in the oil. Some of his oil is recovered by a centrifugal drum or filter
672 press. The process is far too expensive to be of practical value.

(*b*) Pulp treated with oil; concentrates separated (598—520) from surface.

The two Elmore patents depend on oil buoyancy flotation pure and simple, and they differ from each other that in the one no acid is present, whilst in the other one an acid is present. Only heavy oils are used. The extraction of the ore with oil is repeated so often until the tailings are clean. The quantity of oil used in these processes is roughly three tons of oil to one ton of ore treated, assuming an ore such as Broken Hill ore is treated. A large quantity of this oil is recovered by centrifugal separation. It appears from the testimony that this process was practically used to some extent, but abandoned long ago.

The Glogner patent describes a process for purifying graphite

from its natural mineral impurities. The heavier impurities have to be removed first before the material is submitted to treatment. It is then mixed with three or four times the quantity of water and petroleum is added in a quantity amounting to one-half the quantity of pure graphite contained in the ore. The mixture is contained in a suspended vessel, which is moved like a pendulum by hand at a speed of 30 shocks per minute, which movement induces the sunken mass to turn over and to come into contact with the petroleum. After settling, the petroleum, which contains part of the graphite, is removed and the operation is repeated once, twice or more, each time after the addition of fresh petroleum, until the graphite
673 has all been separated from the mixture. The process results in the removal of the graphite by buoyancy (599—521) oil flotation.

Good's invention refers to an apparatus for separating graphite or other materials from associated impurities. He does not say what the other materials are and describes the use of his apparatus only for graphite. He makes the separation in three steps: (*a*) by surface tension flotation on water without the use of oil; (*b*) by oil buoyancy flotation; (*c*) by preferential grinding of the graphite in a mixture of coarse graphite and sand and separation of the so ground graphite from the sand by a screen. There are no details whatever given of the oil flotation. It is clear from the construction of the tank that it can only be used for oil buoyancy flotation, and, furthermore, that the agitator in the tank can only be used for very slow agitation. Nothing is contained in this document which has any bearing on the patent in suit, and, even with the knowledge of to-day, the apparatus described could not be used to produce the effect of the patent in suit. It is a patent only for an apparatus.

Kendall describes another process for the separation of graphite from graphite ores or graphite waste by means of kerosene or paraffin oil, which by reason of its levity carries the graphite to the surface. It is an oil buoyancy flotation process.

(*c*) Pulp treated with oil; concentrates separated from bottom of liquid.

674 Cattermole, No. 777,273, Granulation and Cattermole, Sulman and Picard, No. 777,274, Soap and Granulation, mark a distinct step in advance. They leave the old path of (600—522) trying to effect the separation of the values from the gangue by reason of a reduced specific gravity of the mixture of oil and mineral. They choose the opposite way. They increased the size of the fine particles by agglomerating a number of them together; the oil with which they were coated forming the cement or agglomerant. And in this way they obtained granules of such a size that the law which governs specific gravity and the true falling power in a liquid was established. The values settled on the bottom of a classifier and the gangue, much lighter than the values, was removed by the force of an up-curent. The well-known cone mixer was used for the agglomeration of the oiled particles by agitation, followed by a rolling form of agitation if necessary, the latter to be performed in cylinders or the like. The patentee (Cattermole) warns against the use of lean

ores, and the same warning must apply also to Cattermole, Sulman and Picard process, as the only difference between these two patents is that in the latter the oil is generated in the pulp. The quantity of oil recommended is from 4 to 6 per cent of the amount of mineral present in the ore (1.4 to 2 per cent on Broken Hill ore), but the amount to be used depends on the sort of granules which are desired as well as on the ore which is to be treated. I have found for defendant's ore that a suitable proportion for this Cattermole
675 process, using oleic acid, was from 6 to 7 per cent on the mineral, which amounts to from 1.8 to 2.1 per cent on the ore, and have obtained good granules with these proportions, which are in evidence. The step forward marked by this invention (601—523) was that for the first time the concentrates sank to the bottom of the vessel and that the gangue was floated off. The quantity of oil required, if the quantity recommended by Cattermole is used, is from 28 to 40 lbs. per ton of ore for Broken Hill ore. The quantity which I found suitable for defendant's ore is from 36 to 42 lbs. per ton of ore. I refer to the short ton, unless I state otherwise.

(*d*) Pulp treated with oil; concentrates floated by introduction of gases through pipes or generation of gases in the mixture.

Froment describes some principle embodying the following phenomena:

1. Natural sulphides moistened by oil have a tendency to unite in spherules and to float on the surface.

2. This tendency is retarded by the specific weight and opposed by the gangue in which the moistened sulphides are embedded.

3. The bubbles of a gas generated in this mass become covered with an envelope of sulphides and rise to the surface as a kind of metallic magma.

4. The formation of these spherules is particularly active if the gas used is in a nascent state.

There is no process described in this patent—only a test-
676 tube experiment, from which, however, two important factors can be obtained, namely, the quantity of gas which he wants to generate in a nascent state, and the minimum quantity of oil which he intends to use. He advises the use of 10 per cent of calcite of the quantity (602—524) of ore used, which will provide him with 5 per cent of carbonic acid, and the use of a thin layer of oil which must be at least, according to my actual tests, 12½% of the amount of ore used. The result is obtained instantaneously. Froment was manager of an Elmore concentration plant, and it is clear from the introduction that his invention is a modification of the Elmore process. The result is obtained by oil buoyancy flotation assisted by gas bubbles enclosed therein. Froment describes his float as a magma. Ure's Dictionary of Arts, Manufactures and Mines, gives the following definition of this word:

"Magma is the generic name of any crude mixture of mineral or organic matters, in a thin, pasty state."

This definition is substantially repeated in Murray's and Webster's International Dictionaries, referring to Ure.

The quantity of oil used in the test-tube experiment corresponds as a minimum to 250 lbs. to the ton of ore.

Cattermole, Sulman and Picard, No. 788,247, Soap and Flotation patent, depends on the Cattermole process for oiling the minerals and generally refers to known processes for flotation of the oiled
677 minerals. The quantities of oil used are the same as in the Cattermole patent as a minimum. The phenomenon is skin flotation.

Sulman and Picard, No. 793,808, which has been referred to as the Bubbles patent. This is another skin-flotation process, the skin flotation being produced by a number of apparatus. The quantity of oil must be such that it will moisten the mineral particles; but should be (603—525) less than is required for buoyancy flotation by the oil alone.

The two Kirby patents disclose an apparatus and a process for separating the minerals from the gangue by an oil buoyancy flotation assisted by air blown in through pipes at the bottom of the apparatus. This process is an improvement on Elmore, thin oils being used, which oils can be recovered from the concentrates completely by filtration and by distillation of the concentrates. The quantities of oil specified as giving excellent results are 500 to 1,500 lbs. of oil per ton of ore.

In none of these alleged anticipations is the phenomenon or the process of the patent in suit disclosed. In none of these alleged anticipations is there any suggestion which would lead anybody towards the process or the phenomenon of the patent in suit. In none of these alleged anticipations is there any suggestion that by beating in air a froth could be produced consisting of air bubbles densely covered with minerals and carrying practically the whole mineral contents of the ore. In none of these alleged anticipations is
678 there any suggestion that a quantity of oil could be used so small that it disappeared and could only be detected on the concentrates, by chemical methods.

I repeat that the patent in suit discloses an absolutely novel and unexpected phenomenon, and an absolutely novel discovery which no one could have foreseen.

I will now include in my summary the patents and publications referred to in this evidence, but not referred (604—526) to by Dr. Byrnes.

1. *Apparatus.*

The Wolf patent, No. 787,814, discloses an agitator which has been described in the testimony as the Johnson agitator. This agitator is shown at the upper left-hand corner of the drawing. It works in substantially the same way as a cone-mixer. Instead of a revolving cone, we have a stationary hollow cylinder supported by radial arms, which act as baffles. A revolving stirrer is located below this hollow cylinder.

2. *Processes for Ore Treatment by Means of Water.*

The Hebron patent, No. 474,829, is an improvement on the Hebron and Everson patent, No. 471,174. No oil is used. The ore is prepared by heating or vacuum to drive out the air, and to enlarge the holes or pores alleged to be present in the minerals, and a buoy stock is pressed together with the ore and is supposed to attach itself to the mineral. The mineral containing the buoy stock is
679 separated from the gangue by flotation, according to the statement of the patent. This is the last patent in the Everson series and marks the final and complete abandonment of the use of oil to effect separation.

3. *Processes for Ore Treatment by Means of Oil.*

The Haynes British patent, No. 488 of 1860, contains the first disclosure of the use of oil for ore concentration. The ore is mixed with oil to form a stiff paste, which is then kneaded with water to wash out the gangue. It is not a practical process. (605—527)

The Fryer Hill publication of 1889 is clearly a further development of the Everson patent. It adds to Everson the use of heat. The specific agitator which is described as having arrastre-like fans probably ought to be arrastre-like fans and is derived from the Spanish word "arrastre," which means to drag. The process so far as it can be determined from this publication is open to all the objections of the Everson process as described in the Everson patent.

The Criley-Everson publication of 1890 is a modification of the Everson process as described in the Everson patent, black thick oil being used instead of petroleum, and water near boiling being used. The experiment appears to have been made in a laboratory. There is a clear disclosure of the use of acid in small quantities as in the Everson patent. No practical process of ore separation is disclosed in this scant description.

680 The Robson patent No. 575,669, which appears to have been partly assigned to Crowder, is for a process which has been referred to in this evidence as the Robson, and Crowder process and in this process the ore is moistened with water and then a stream of oil is used to wash out the mineral. On the face of it, it is clear that this process is far too wasteful and expensive to be of any use.

The Cattermole patent, No. 753,260 is known as the Emulsion patent and discloses the use of an oil emulsion in the granulation process of patent No. 777,273. The solution is alkaline instead of acid. This is a division of the application on which patent No. 777,273, was granted, (606—528) and is clearly a variation of the Cattermole process, giving the same proportions of oil as are given in the Cattermole patent No. 777,273.

The other Cattermole patent mentioned by me, No. 763,259, is for the classification or separation of concentrates or granules obtained by the Cattermole process, that is, the separation of the different sulphides from each other. This is effected by retreatment

of the granules in an apparatus substantially the same as is disclosed in the other two Cattermole patents with the use of a breaking down solution. This process starts with oiled granules, and is not a process for the separation or concentration of the values contained in an ore.

I can only repeat here what I said at the end of my preceding answer. These patents and publications do not disclose or
681 suggest the invention disclosed in the patent in suit. They give further examples of the efforts to solve the problem of ore concentration by oil and of the failure to do so in a practical and economical manner.

Relative to the criticism by Dr. Byrnes that the conclusions which Prof. Chandler drew from his very exact experiments with defendant's ore, are based upon pure speculation, I must frankly confess that I cannot follow the bent of his mind, which led him to say this. Dr. Chandler made an analysis of defendant's concentrate by a recognized method, which cannot be improved upon, and drew his conclusions from the results which he obtained. He confirmed the correctness of his conclusions by a series (607—529) of well-conceived experiments which could not be improved upon, and I accept his results as facts, as everyone else who knows the great reputation of Prof. Chandler both here and abroad will do.

46 Q. Have you read the depositions of Edward H. Nutter, Jesse C. Gibson and James M. Hyde, and the descriptions therein of the apparatus referred to by defendant's witnesses as defendant's experimental plant, from which apparatus Mr. Nutter testified that he took a sample of froth while the apparatus was in operation, and do you understand the construction and operation of said apparatus?

A. Yes.

47 Q. Could this apparatus be used for any of the processes of the patents and publications referred to by you, except the agitation-froth process disclosed in the patent in suit, so as to produce a
682 flotating froth in the spitzkasten of the type described by Mr. Nutter in his deposition?

A. No.

48 Q. Assuming that powdered ore, water acidified with sulphuric acid, and oleic acid are fed into the defendant's apparatus referred to and that a floating froth of the type described by Mr. Nutter appeared on the spitzkasten, what have you to say as to the process being carried out under such conditions in defendant's apparatus?

A. I say that a froth thus produced must have been produced by the process of the patent in suit.

49 Q. As I understand it, you have read all of the (608—530) deposition of Dr. Byrnes in behalf of defendant and are therefore familiar with that part of this deposition wherein defendant's second plant is described?

A. Yes.

50 Q. I now repeat Q's 47 and 48 as applicable to defendant's second plant described by Dr. Byrnes.

A. My answers are the same as to those questions.

51 Q. What have you to say as to the suggestion that the retreat-

ment of concentrates and of the residues obtained from the retreatment of concentrates, constitute, either separately or collectively, a departure from or an improvement on the agitation-froth process as set forth in the patent in suit?

A. The retreatment of the concentrates and of the residues obtained from the retreatment of the concentrates does neither constitute a departure from nor is an improvement of the agitation froth process as set forth in the patent in suit. It is a mere repetition of the process carried on with material containing different quantities of mineral and gangue.

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Relative to the statements of the defendants James M. Hyde as to an odor of sulphuretted hydrogen in connection with his operations, I have noted this odor to a very slight extent in my tests of defendant's ore. This odor is not due to the decomposition of the valuable sulphides, but to some other sulphide, probably an iron sulphide which is present in the ore and quite valueless. There is not a trace of the valuable sulphides attacked by the dilute acid present in the pulp mixture. Some suggestion (609—531) has been made in the evidence that sulphuretted hydrogen or hydrogen sulphide might be used like carbonic acid in statu nascendi, that is, in the nascent state, as a suitable gas for carrying oiled minerals to the surface. That is not so. Sulphuretted hydrogen is comparatively soluble in water, but that might be overcome. The reason why sulphuretted hydrogen cannot be used for this purpose is that it is dangerous to human life. It is one of the most dangerous poisons in existence and I know of several cases in which the leakage, and that a very small one, from a closed vessel caused the loss of human life. To use this gas for the concentration of ores would, if it were done, soon put an end to the concentration process. The very trifling quantities that can be produced in defendant's plants may be unpleasant to the smell, but it is impossible that they contribute in any way to the process of ore concentration. There can only be the very faintest traces of this gas; otherwise it would have a bad effect on the workmen, and from this ore and under these conditions only the very faintest traces of this gas can be produced. Such very faint traces are appreciable to the smell. That is all. It has been a well-established fact, since the time of Everson's discovery, that the presence of acid in a mixture of pulp and oil cuts the gangue out, and it has been well known that the presence of acid in a mixture of pulp and oil prevents the oiling of the gangue, and that is the purpose for which acid is present. If an ore contains calcite, which is an easily decomposable carbonate, then the amount of acid must be larger than if there was (610—532) no calcite present, in order to enable the sulphuric acid to fulfill its mission, namely, to prevent the gangue from being oiled. In defendant's ore rhodochrosite, or manganese carbonate, is present to a slight extent, and I have proved experimentally that it is at lower temperatures not readily attacked by dilute sulphuric acid. But if the whole quantity of sulphuric acid which defendant uses would act and produce carbonic acid, there is so much water present during the transit of the

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mixture of ore and water to the pulp thickener that it would merely pass into solution or into the air. It could not remain in contact with the enormous excess of water without being dissolved, and it would certainly be dissolved during the agitation process later on. This is also true as to sulphuretted hydrogen, if any traces of it should be formed, and, as I have said, nothing but the merest traces of it could appear in defendant's plants.

635 I am convinced, from my analysis of the gaseous content of the agitation froth, the air is the agent which forms the froth, and that the presence or absence of small quantities of other gases has no effect whatever in the production of the froth, while the consumption of sulphuric acid, which would produce these gases, is a serious detriment to the economy of the process.

As to the statements of Dr. Byrnes that the patent in suit does not guide one as to the amount of acid to be used, I say that this statement has no significance whatsoever. I always understood that a patent was addressed to persons conversant with the particular art with which it (611—533) deals. Metallurgists know that ores are not individuals, but mixtures. Metallurgists know that an ore may contain small quantities of an acid-absorbing substance. It would be impossible for any patentee to give definite amounts of acid in a patented process dealing with a large variety of ores. He can only state for what purpose the acid is present and it is for the metallurgist to obey the instructions of the patentee and to see that there is acid present whilst he performs the process of the patent, and to see that the acid is not consumed by secondary reactions. If the secondary reactions cannot be avoided, more acid must be used, so that there may be free acid to perform the functions which the patentees wish it to perform, if it is to be used.

The statements of the patent in suit as to the use of a 636 powdered ore is well understood amongst technical man. If the substance is to be powdered, that is, finely crushed, it is usually done with water, if water has no influence on the substance, that is, neither destroys it, nor dissolves it. It is much easier to crush with water than without water. Powdering means reducing to a fine state of division, and it does not matter whether it is done dry or wet.

56 Q. The defendant has put in evidence a patent granted to him on April 2, 1912, No. 1,022,085. What have you to say as to this patent?

A. I say that this patent contains a description of the process disclosed in the patent in suit.

The patentee calls first attention to the fact that (612—534) certain metallic and nonmetallic elements differ from each other in their behavior to oils and fats, that the metallic substances are wetted thereby, and that they can be separated from the gangue by markedly different surface tension phenomena.

The patentee then states that many ores containing a number of mineral components show, when crushed, that the resulting pulverized material consist of particles which are so fine and of such a colloidal nature that they settle very slowly and interfere with ob-

taining a high-grade concentrate by the use of a flotation proces
The patentee says he has discovered that this settling is greatl
promoted by the introduction of a small amount of sulphuric aci
with or without some salts, to a pulp whilst in transit to the flot
tion device, and he enumerates the advantages which h
687 obtains by this treatment, namely, the partial or complet
coagulation of the slimes, which makes the thickening of
pulp possible in the pulp thickener, greater facility in separatin
the concentrates from the gangue, cleaning of the surface of th
particles of the floatable minerals, and assisting, by the generatio
of minute bubbles of gas in the pulp and on the surface of th
floatable mineral particles, in the desired separation of the mineral
from the gangue. The next sentence is a little bit difficult to under-
stand and the conclusion more so, but the assertion is made that
by the addition of the acid to the pulp before it reaches the flotation
plant a smaller amount of acid may be used, "as little as one quarte
of a pound of crude acid per ton of ore treated" (page 1, line
77-79). (613—535)

A further discovery is announced that the concentrates produce
can be retreated with the same process, without in certain cases th
use of additional acid or coating agent. The oils suitable for th
process are the oils which have been used in former oil ore-separa
tion processes.

The plant shown is substantially the same as in the Hoove
patent, No. 953,746, which appears on its face to have been issue
to Minerals Separation, Ltd., one of the complainants, except tha
in the drawing only one agitating box is shown for each spitzkaste
whereas in the Hoover drawing three agitation boxes are show
for one spitzkasten, but the Hyde specification says tha
688 "each of the agitator tanks may, if necessary, consist of
plurality of connected compartments, each provided with
an agitator."

This suggested modification makes the plants the same, except
that the deflector K of the Hoover drawings is omitted, and except
also that the Hoover apparatus is repeated so that there are three
units in the rougher or first treatment apparatus, and two units in
the cleaner or retreatment apparatus.

In the agitator the mixture of pulp and oil is agitated and flows
from there through an opening at the bottom into the spitzkasten,
in which the froth rises to the top whilst the tailings collect at the
bottom and are removed from there by a pump into the next agi-
tator, where they are reagitated and the treatment is repeated. The
froth which rises to the surface of the spitzkasten flows into a
launder and from there through a pipe into the first (614—536)
agitator of the cleaner or retreatment apparatus. The froths which
form on the second and third spitzkasten of the rougher system,
flow also into the first agitator of the cleaner system, and the opera-
tion is repeated in this system exactly as in the rougher system
with this distinction that there are only two agitators and tw
spitzkasten. The froth is collected from there and is ready for th
smelter, and the tailings, which are called middlings, are pumpe

from the bottom of the last spitzkasten into the first agitator of the rougher system to pass again through the treatment of concentration.

689 The two alleged novelties are treatment of the pulp with sulphuric acid before it reaches the flotation plant and retreatment of the concentrates.

As to the first, namely, the settling of slimes and preparation of the pulp by treatment with sulphuric acid, this is described in Richards' Ore Dressing, a standard work in metallurgy, and appears in Volume II, section 869, pages 1147, 1148, which on the title page is stated to have been published in New York and London in 1905. I quote the following which is given as a test of the use of sulphuric acid for the purpose of settling an ore pulp:

"Time of settling, ½ hour; sulphuric acid 0.15 per cent, 100; sulphuric acid 0.29 per cent, 96; sulphuric acid, 0.57 per cent, 99."

I have taken these figures from the table and the numbers 100, 96 and 99, respectively, represent the percentages of total slimes settled out during this period of one-half hour with the respective proportions of sulphuric acid stated. This shows that a very small percentage of sulphuric acid gives the best results. (615—537)

A metallurgist, wishing to thicken his pulp and to save his slime, would add his acid before the pulp goes into the pulp thickener or dewaterer, and that is just what the patentee Hyde has done.

An advantage claimed by the patentee Hyde for the addition of sulphuric acid before the pulp is mixed with oil is

"the cleaning of the surface of the particles of the floatable minerals"

690 before they are submitted to the oiling treatment. I call attention to the British patent No. 17,328 of 1906, granted to Minerals Separation, Ltd., as a communication from George A. Chapman. This patent specifically refers to the British patent for the agitation-froth process, No. 7803 of 1905, corresponding to the patent in suit, and describes as an improvement upon it that better results are obtained if the pulp is first agitated with acidified water and the treatment with oil postponed to the second or later agitator.

Another advantage claimed by the patentee Hyde for the addition of sulphuric acid before the pulp is mixed with oil, is that minute bubbles of gas are generated in the pulp and on the surface of the floatable mineral particles, which bubbles assist in the desired separation of the mineral components of the ore. This statement is not in accordance with fact. The quantity of gas which can be generated by the quantity of sulphuric acid stated as being used is so small that it could be ever so often dissolved by the quantity of water present, and what is not dissolved (616—538) will escape into the air.

The other alleged novelty of the Hyde patent is the retreatment of the concentrates by the same process by which the original ore was treated. There is no novelty in this. It is a characteristic of the agitation-froth process that the quantity of oil is so minute

and so firmly attached to the metallic particles that they can be agitated over and over again without removal of the invisible oil films on the particles. Reagitation of a dirty concentrate is
691 simply re-agitation of an ore pulp which is richer than the original ore pulp, and return of the residue of middlings from the agitation of such a dirty concentrate is simply good metallurgical practice if anything can be gained by it, and it is the ordinary practice in any well conducted factory.

57 Q. Please now briefly describe patent No. 979,857 issued to Minerals Separation, Ltd., as the assignee of Theodore J. Hoover, on December 27, 1910.

A. This patent discloses an apparatus for carrying on the process of patent in suit, and shows a combination of agitators and spitzkasten with six agitators and three spitzkasten arranged in very nearly the same relation as in Defendant's Experimental Machine, the only difference in arrangement being that each spitzkasten has two agitators in series instead of the successive spitzkasten having three, two and one agitator, respectively.

An offer is now made by complainants' counsel to repeat in the presence of defendant and his counsel (617—539) any of the tests or experiments testified to by the witness, this offer to be availed of at any time during the cross-examination.

It is stipulated that Volume II of Richards' Ore Dressing, referred to by the witness, was published and circulated during the year 1905. Sec. 869, appearing on pages 1147 and 1148, of Richards' Ore Dressing, the book referred to, is offered in evidence to be replaced by a copy thereof, marked "Complainants' Exhibit, Extract from Richards' Ore Dressing," and the entire book is handed to defend-
692 ant's counsel for use in cross-examination.

Cross-examination:

Referring to my first experiment in a test tube using the proportions and materials of Dr. Byrnes' first slide machine test alleged to represent Froment, this experiment was not performed with the intention of producing a froth. This experiment was performed with a view of finding out whether the quantities which Dr. Byrnes had used were such quantities as would come under the Froment patent, and whether the Froment result, namely, a magma, could be obtained. I was convinced that it could not be obtained, and the result proved that I was correct. (618—540)

63 X Q. In performing this experiment, it was not the fear of an excessive generation of carbon dioxide that caused you to limit the period of agitation to two seconds and to an additional six or eight seconds. Am I right in this?

A. No. I did not limit the time of agitation. According to my reading of the Froment patent, I extended the time. If the Froment quantities are taken, as described, two seconds is ample time to see the phenomenon which he has described. It is an instantaneous reaction.

66 X Q. Is the reaction between sulphuric acid of the strength

resulting from mixing a few drops of sulphuric acid with 30 grams of water and a carbonate always instantaneous, regardless of the character of the carbonate, that is, regardless of what base enters into the carbonate, regardless of the condition of the carbon-
693 ate as to its state of crystallization, or whether it is a precipitated carbonate? I may also add to this inquiry whether the quickness of the reaction is not also related to the temperature.

A. No. The difference, for instance, of crystalline structure and amorphous structure makes a difference in the evolution of the gas. For instance, if you use precipitated carbonate of lime or marble, there is a difference in evolution. The difference between different carbonates is also marked. For instance, limestone in finely powdered condition is much more readily attacked than crystallized manganese carbonate. Heat nearly always favors chemical action. Then there is another important factor, whether the acid is used in more concentrated or more dilute form. There are numbers of instances known in chemistry in which acid of a certain dilution fails to produce a result, which in more concentrated form is easily produced. Froment was (619—541) fully aware of this difference in the behavior of carbonates.

67 X Q. And any metallurgist or chemist, even of comparatively low qualifications, would be aware of the different behavior of different carbonates under the different conditions to which you have referred in your preceding answer, would he not?

A. Quite so, and that is the reason why Froment advises the addition of limestone to the ore.

68 X Q. I understand, therefore, that your statement in answer to X Q. 63, embodied in the words "it is an instantaneous
694 reaction," is not a statement of universal application, but merely refers to the fact that, when a proper carbonate in a proper condition is selected, and the proper acid in its proper condition of dilution is selected, and when the temperature is adjusted at the proper point, a practically instantaneous reaction may result. Is my understanding of your answer correct?

A. My answer to X Q. 63 is quite clear:

"If the Froment quantities are taken, as described, two seconds is ample time to see the phenomenon which he has described."

It clearly refers to limestone. Other carbonates may result in instantaneous action if the proper conditions can be found.

69 X Q. Do you find anything in the British Froment patent to indicate to the metallurgist that an instantaneous reaction would take place between sulphuric acid of the dilution used by you in the experiment referred to in X Q. 63 and your answer thereto above referred to, and the kind of carbonate contained in the ore used by you in that experiment?

A. I find from the British Froment patent that the (620—542) quantity of acid used in this experiment would be absolutely useless for the production of the Froment result, namely, the production of metallic spherules to form a magma clearly separated from the rest of the liquid.

70 X Q. The amount of acid necessary to react with a given quan-

tity of carbonate involves only elementary knowledge, does it not, and is something that would be obvious to any chemist or
695 metallurgist, even one of comparatively slight qualifications?

A. Yes, the amount of acid is determined by the amount of carbonate which is to be decomposed. That is knowledge which every beginner ought to have.

71 X Q. And if, in following the directions of the Froment British patent, the operator were to use some carbonate that did not readily react with the acid employed, it would be obvious to him, would it not, that he should adjust the temperature and other conditions to the point favorable to such reaction?

A. No, that is not at all obvious. If it were only the intention to produce carbonic acid, then such adjustment would be permissible. But if it is only an incident in a different and novel process, which depends or may depend on other conditions and reactions, then such a proceeding would not be obvious.

72 X Q. If the operator, in carrying out the process described in the Froment British patent according to the directions therein contained, found that there was no reaction or a very slight reaction between the acid and carbonate, these being present in the proper proportions, would it not be obvious to him, if he desired to promote the evolution of carbonic acid, to apply heat to the mixture upon the presumption that the temperature was too low? (621—543)

A. That is not the way I look upon such a proceeding. In my view, the obvious thing to do would be to add the limestone
696 as prescribed by the patentee. That seems to me the only fair way of carrying out the instructions contained in an example of a patent, unless the patentee directs you to do differently.

73 X Q. In dealing with this subject of temperature, do you intend to convey the idea that the metallurgist, in carrying out the process of the Froment patent, is not, according to your idea, expected to utilize his elementary knowledge of the art, including his knowledge of the elementary principle that the reaction between many substances, including that between a mineral acid and a carbonate, is in many instances dependent upon the temperature of the reagents?

A. The metallurgist is, in my view, not entitled to use heat in a process such as the Froment process. There are physical phenomena involved in this process to which heat might be detrimental. As I said, if it were a process simply for the production of carbonic acid, that would be a different matter, but it is not so. The very fact that Froment describes the addition of limestone is sufficient for metallurgists to see how he wants the process carried out. There is no earthly reason why a metallurgist should deviate from the prescription.

74 X Q. Do you consider the evolution of carbon dioxide so unimportant a detail of the process of the Froment British patent that the metallurgist would not be expected to utilize his elementary knowledge to an extent sufficient to adjust the temperature and other conditions to that point where carbon dioxide would be
697 evolved, as directed by the patentee?

A. The generation of carbon dioxide is the important

(622—544) factor which enables Froment to carry out his invention, but the real process begins only with the utilization of the carbonic acid produced, and the question of temperature might have a very serious effect on the result. I repeat that, in my view, no metallurgist should deviate from the process as described. I consider the evolution of carbonic acid as directed by Froment as an important factor in the Froment process.

75 X Q. The evolution of carbon dioxide being an important factor in your view of the Froment process would it not be the obvious thing for the metallurgist to adjust the temperature and other conditions to the point where this important factor would be present?

A. No, it would not be an obvious thing to do. The obvious thing clearly is to carry out the process as described by an inventor.

The temperatures which the patentee intends to use are normal temperatures, such as they occur in places where operations of this kind are usually carried out. Such temperature may vary within certain limits, but I believe that the usual temperatures are somewhere about 15° to 16° Centigrade (59° to 61° Fahrenheit); it may be a few degrees up or down.

81 X Q. Do you find anything in the Froment patent to the effect that this process is to be carried out at a temperature of 59 to 61 degrees Fahrenheit?

A. Yes, most decidedly so. The very absence of instruc-
698 tions means that the process is to be carried out at ordinary temperatures, and the very addition of limestone, which so readily decomposes at ordinary temperature, is further proof of it. If heat were applied in this case, the result would be what he warns against. (623—545)

85 X Q. I understand that, if the carbonate selected by you did not generate carbon dioxide at a temperature of approximately 59 to 61 degrees Fahrenheit, at the same rate that carbon dioxide is generated from calcium carbonate at that temperature, you would consider yourself outside of the instructions of the Froment patent in using such other carbonate. Is this correct?

A. I have stated that the directions of the patentee are to use the normal temperature and that he must have had reasons for giving them. It is a well-known fact, especially with regard to ore concentration by means of oil, that the temperature is of importance, and it was especially known to Froment, who was manager at Traversella Mine, where the Elmore process was worked. In the Elmore process heat is fatal to the result. The question whether anyone is outside the patent if he deviates from its instructions, is for the Court. As a conscientious person, to work the Froment patent I should follow the instructions of the patent.

87 X Q. I take it from your answer that you believe the information to be derived from the Froment patent by a metallurgist is con-
fined to the use of limestone as a source of generating carbon
699 dioxide, and that this patent would not teach a metallurgist that other sources of carbon dioxide might be used or that other gases than carbon dioxides might be used. Am I correct in this?

A. I have stated in my direct evidence that this patent is rather a complicated document. It consists of a theoretical speculation and contains as a description of the process a test tube example. From the theoretical speculation, one may infer an absolutely different process, but (624—546) there is no such process described anywhere, and the only help which a metallurgist gets from it is the test tube example. I will avoid another question and say, that in that part of the patent which I have called theoretical speculation, it is stated that:

"If a gas of any kind is liberated in this mass, the bubbles of the gas become covered with an envelope of sulphides and thus rise readily to the surface of the liquid where they form a kind of metallic magma,"

that might imply the use of other gases, but I know of no other gas which could be liberated in this mass except carbonic acid and sulphuretted hydrogen, and the latter is quite out of the question. I repeat that, with the exception of the test tube example, we find only theoretical speculation in this document.

88 X Q. My question was directed to ascertain, in the first place, whether you believe in information to be derived from the Froment patent by a metallurgist is confined to the use of limestone as to source of carbon dioxide in case carbon dioxide is to
700 be used. Will you kindly answer that question?

A. I do.

89 X Q. Referring to the experiments performed by Dr. Byrnes, numbered 3, 4 and 5, in test tubes, and stated to be made in connection with the Froment patent, you have said, "I disagree with the result described, which I could not obtain." Will you describe what operation you performed which resulted in failure to secure the results described by Dr. Byrnes, namely, the production of a froth?

A. Dr. Byrnes' Experiments 3, 4 and 5 are represented as experiments of the Froment patent. I disagree with this description. They are not experiments of the Froment patent. In experiment 3, he mixes the Black Rock ore with (625—547) water. In experiment 4, he adds sulphuric acid to the mixture of ore and water and heats the mixture; that is, he removed the agent which is essential to the Froment process, namely, carbonic acid in the nascent state. Then he waits until the Potter and Delprat result which occurred, namely, the appearance of mineral on the surface of the liquid, has disappeared and the mineral has again returned to the bottom, then he adds one drop of olive oil to the mixture and agitates. He then states that he obtained the magma or froth as described in the Froment patent. That is utterly impossible, for the following reasons: Froment describes ordinary temperature, he describes the formation of a magma by the use of carbonic acid in the nascent state, he describes a layer of oil to be used,
701 and Dr. Byrnes has not followed one of the instructions. I repeat that he could not have produced the Froment magma

and that he did not produce it, and, finally, I say that aeration, as Dr. Byrnes describes it, is absolutely foreign to the Froment patent.

When I performed such an experiment, I did not obtain the Froment magma, but the agitation froth of the patent in suit, and the result was not due to carbonic acid, but to a prolonged, vigorous agitation.

90 X Q. Did this agitation froth which you secured contain bubbles of gas covered with an envelope of sulphides?

A. This agitation froth contained bubbles of gas covered with an envelope of sulphides, and it differed in this respect from the magma obtained according to the Froment test tube example. It was perfectly stable, the minerals were brilliant and had a metallic lustre. When it once appeared on the surface, it stayed, and when sunk by force (626—548) it could be reobtained by vigorous agitation. The Froment magma is more like an oily layer containing bubbles of carbonic acid, which are enclosed in oil, in which the minerals are embedded. The magma is not lasting. In the agitation froth, no oil can be discovered. If it is put on blotting paper, it dries, but it retains its shape. If the Froment magma is put on blotting paper, the oil soaks into the blotting paper and leaves a large spot, and the bubbles collapse. In the agitation froth, the film enclosing the air is water, which is protected and
702 strengthened by a dense layer of the minerals. In the magma there is a layer of oil, which contains carbonic acid bubbles, and the film enclosing them is oil covered with minerals. The difference between the two is that the agitation froth is lasting, whilst the bubbles contained in the magma are not.

91 X Q. On what observation or experiments, if any, do you base your statement that, in the practice of the Froment process, as you interpret that process, the carbonic acid bubbles are enclosed by oil, while in what you term the agitation-froth process the films of the bubbles are composed of water?

A. I base it on my personal observations.

92 X Q. In the operations which you have so observed, how much oil and what kind of oil did you use?

A. I remember having used oleic acid and cottonseed oil, but I am almost sure that I have used a number of other oils. In the Froment process I have used the thinnest layer which could form in a proper test tube, namely, 12½ per cent of oil to the amount of ore used.

93 X Q. How by observation are you enabled to determine whether the film of a bubble which is covered with an envelope of sulphides is formed of water or of oil? (627—549)

A. That is comparatively quite easy with Froment, and Froment himself, in what he calls his principles, teached you how to do it. If you mix your ore, limestone and oil and water together, the oiled minerals fall to the bottom. If you then add sulphuric acid,
703 you can observe how the gas slips into the oil and how, in this way, the bodies are formed which are justly characterized, by Froment, as spherules, little spheres. In the agitation-froth process, oil seems to be absolutely absent and it can only be dis-

covered by chemical analysis. The films, therefore, must be water films.

94 X Q. Will you state at what point in the operation described in that paragraph of the Froment patent immediately below the paragraph numbered "4" the oiled minerals fall to the bottom of the test tube, in your answer taking into consideration Froment's statement that

"the whole — the copper pyrite will instantly rise to the top of the liquid"?

A. The test tube example is clearly described as resulting from the principles laid down in the four paragraphs preceding it. It begins,

"Thus, for example."

I have carried out both the suggestions which are laid down in the four principles, and the process of the test tube example. The result is identical. There is no operation described in the test tube example saying that the oiled minerals fall to the bottom. The reaction proceeds so quickly and is so instantaneous that such a phase cannot be observed.

95 X Q. The matters set forth in the paragraphs of the Froment patent numbered 1, 2, 3 and 4 are introduced by the patentee's statement that the following phenomena studied by him have served as the basis of the process (628—550) which forms the
704 subject of his invention. Would you not, from this statement, understand that the four numbered paragraphs are merely statements descriptive of certain phenomena as distinguished from a description of a method of procedure, and would you not understand that the paragraphs following the four numbered paragraphs are a statement of practical procedure?

A. I should understand from the statement of the four principles which you have mentioned and the beginning of the example "thus, for example," that the patentee wishes you to understand that these are the actual facts underlying the test tube example.

96 X Q. Do you find in the Froment British patent any description of a method of carrying out his process, that is, a description of any series of practical operations other than that contained in the paragraph following the four numbered paragraphs?

A. To be quite frank, I do not find any practical process in the Froment document. There are the four principles which would suggest working in a number of steps. Then there is again a suggestion at the end of example 2, from which one can infer that he might mean the process to be in a sequence of steps. And then there is the claim, which again claims only a sequence of steps. Yet, there is no description of any process containing or being based on a sequence of steps. The only process I find is a test tube example, and that is not a practical process.

98 X Q. In your experiments following Froment's description of his test tube operation set forth in the British patent,
705 were you able to form some idea by observation as to whether

ou succeeded in separating a substantial part of the metalliferous ineral by flotation?

A. I have no doubt that a substantial part of the (629—551) inerals was obtained on the surface, but I should not like to say or uess how much it was. The magma was not lasting and part began o fall, one might say, at the moment of its birth.

99 X Q. What do you consider a layer of oil found on the top f water in a test tube—sufficient oil to cover the entire meniscus and o contact with the walls of the test tube, or an amount covering the ain body of water in the test tube?

A. In my view, there cannot be two definitions of a layer. A layer f oil is an amount of oil which will cover the surface of the water. Otherwise, it would be called a blob or a globule. There are not two efinitions possible.

100 X Q. Do you find that Froment, in his British patent, anywhere stated that the layer of oil must cover the entire surface of the ater in the test tube?

A. There was no description necessary; the language is quite intelligible. Apparently it did not matter to Froment whether more il should be used, because he does not call it the thinnest layer, but a thin layer. I used nearly always the minimum quantity, namely, he thinnest layer of oil.

101 X Q. In your operations conducted along the lines of
706 Froment's test tube operation, using 12½ per cent of oil of the ore, did you obtain the result described in the third numbered paragraph of the Froment patent, namely, bubbles of gas covered with an envelope of sulphides?

A. Always, with the exception of once or twice when the contents of the test tube were blown out. There was always a layer of oil with the Froment spherules embedded in it. Froment calls the bubbles of gas covered with an envelope of sulphides, metallic spherules. (630—552)

103 X Q. You have stated that your first experiment in a test tube using the proportions and materials of Dr. Byrnes' first slide machine tests alleged to represent Froment, was not performed with the intention of producing a froth. What difference in procedure would you have followed in performing that experiment if it had been your intention to produce a froth?

A. It is correct that this experiment was not performed with the intention of producing a froth. If I should have wanted to produce a froth, by which I assume you mean an agitation-froth, I should have taken larger quantities of ore, the proper quantities of oil and I would have shaken in a stoppered-up bottle. It is scarcely possible to produce an agitation-froth in a test tube, as a test tube almost always breaks. Then my usual practice was to give the bottle at least a hundred shakes and if no froth had appeared then, I would have continued shaking for fifty times more, and would have made
707 another observation. That is the way I usually carry out experiments which were intended to result in an agitation-froth.

104 X Q. In performing the experiment above referred to, using

the proportions and materials of Dr. Byrnes' first slide machine te
did you place a stopper in the test tube?

A. I put the lower end of my thumb on the opening of the te
tube and closed it up.

105 X Q. Then there was no stopper in the test tube other tha
the closure formed by your hand?

A. That was the only proper stopper to use, according to the Fr
ment description. Froment says that sometimes the contents a
ejected from the test tube. That (631—553) can only mean suc
closing up or warning not to have a stopper on and do it in the wa
I described, and I may add it is the ordinary way, that these exper
ments are always carried out in a laboratory. No other stopper tha
my thumb was used.

106 X Q. To state the matter simply, I understand that you di
not use a stopper in the test tube because Froment did not mentio
a stopper and because you feared, in view of Froment's warning, a
you term it, that it might have been dangerous to use a stopper. I
this correct?

A. I used my thumb because that is the usual way one does suc
tests, and it is the only convenient way to gradually reduce certai
gas pressure without detriment to the experimenter. I did not expe
Froment to describe a stopper. I only knew from the warn
708 ing that we might expect a certain gas pressure.

112 X Q. In any of your investigations of this subject di
you agitate in a test tube the substances mentioned by you in you
test tube repetition of Dr. Byrnes' experiment for a period longe
than seven seconds?

A. In none of my experiments referring to the Froment patent
or to questions arising out of the Froment patent, did I shake for
longer period than I mentioned, and in each case, where I followe
out the Froment directions, I obtained the result within two seconds.

113 X Q. By "the result," I presume you refer to having all the
ore at the bottom of the liquid and some oil containing slimes on the
top, this being the result you have described as being obtained in the
operation under discussion.

A. The assumption of counsel that I have considered these experi-
ments as Froment experiments is not correct, and I regret that my
description of them and the reasons (632—554) which induced me
to make such experiments have been such as to mislead counsel. To
avoid a further misunderstanding, I will now speak out in such lan-
guage that such a misunderstanding cannot occur again. I consider
the experiments of Dr. Byrnes, of which these test tube tests are the
translation into the quantities of the test tube example, as utterly
absurd and not at all representing anything which Froment de-
scribed or which could arise out of the Froment description.
709 It has always been my habit in such cases to treat the opin-
ions of experts on the opposite side with courtesy, and I have
always refrained from sharp criticism. I am sorry that this habit of
mine, which I cannot alter at my present age any more, should have
produced such a misleading impression in counsel. I repeat that
the experiments introduced by Dr. Byrnes have nothing to do with
the Froment patent. The result which I obtained when operating

according to the Froment instructions was not what is stated in the question, but a magma clearly separated from the rest of the liquid.

I have never made any test tube experiments with the substances and in the proportions mentioned by me in my test tube repetition of Dr. Byrnes' experiments otherwise than as described in my testimony regarding these experiments. I have no notes that I varied the time referring to the specific example mentioned by you, and my memory is that they were exactly repeated.

I have made a number of experiments in which I used more than one per cent of oil in proportion to the quantity of ore used. They refer to the alleged anticipations which have been produced by the defendant. I find one note in which I say "50 grams of ore, 150 cc. of water, (633—555) ½ gram of sulphuric acid, 1½ grams of oleic acid, all at bottom." This experiment was made on 22d of July, long before I had read the evidence of Dr. Byrnes.

710 I have another experiment here in which I used 400 grams of ore, 1600 grams of water, 4 grams of sulphuric acid and 12 grams of oleic acid. This experiment was carried out in a cone mixer, and the agitation lasted two and a half minutes. The temperature was 44° centigrade. The remarks are:

"No froth; granules below sand."

This experiment was made on the 23d of July, long before I had any knowledge of Dr. Byrnes' evidence.

On the same day I made an experiment with the same quantities, except the quantity of oleic acid. That was 20 grams. The temperature was 40° centigrade. The remarks are:

"No froth; granules heavy, much heavier than sand; granules formed bigger during agitation."

This latter part must mean during continued agitation.

Then I have an experiment on the same day. The quantities the same as before, with the exception of the quantity of oleic acid. That was increased to 40 grams and the remarks underneath are:

"Granules getting bigger and heavier; thin layer of oil on surface."

Where I used 50 grams of ore and 1½ grams of oleic acid, the proportion was 3% of oil as compared with the ore.

Where I used 400 grams of ore and 12 grams of oleic acid, the proportion was 3% of oleic acid.

Where I used 400 grams of ore and 20 grams of oleic acid, the proportion was 5% of oleic acid.

Where I used 400 grams of ore and 40 grams of oleic acid, the proportion was 10% of oleic acid. (634—556)

711 These examples could be continued, but I should like to specifically mention the experiments made with special reference to the Cattermole patent. The quantities of oil used therein are within the limits of your question. The experiments described were made by me only for the purpose of study.

Colza oil, mentioned in Robson U. S. patent 575,669, is rape oil. Rape oil is a fatty oil, and the expression "a fatty oil such as Colza oil" appearing in the Robson patent 575,669 would include olive oil and cotton-seed oil.

I have used in agitation-froth experiments mostly oleic acid. I have also used in agitation-froth experiments cotton-seed oil, viscous

valve oil, palm oil, lard oil, pinoline, linseed oil, eucalyptus Tex residue oil, turpentine.

I have used for Cattermole, and for flotation and for washing o experiments other than agitation froth "Texas fuel oil, oleic aci cotton-seed oil, crude petroleum, Summer dark oil, a mixture of Tex fuel and paraffin wax, petroleum, a mixture of kerosene and Trinid asphalt and engine oil.

These are the substances which I can remember.

139 X Q. Will you answer my preceding question with referen to the substances you refer to as "engine oil," whether this substanc known as mineral engine oil, is one of uniform composition o whether you would expect it to vary when obtained from differen sources at different times?

A. I should not expect this substance to be a definite chem
712 ical compound. It is required to possess certain physica properties suitable for the uses to which it is put. (635—557

Pinoline is a hydrocarbon belonging to the turpine series. It is very thin vegetable oil made from pine trees by distillation. Tar o is a result of the destructive distillation of coal. It contains a numbe of substances. I am also familiar with a tar oil derived from woo by destructive distillation.

153 X Q. In operating upon any ore containing a sufficiency of carbonate, would you, in applying the process of the Froment Britis patent, add a carbonate thereto in addition to that naturally o curring in the ore?

A. It all depends on the nature of the carbonate. If, for instanc sodium carbonate were present, I should wash that out and not us it. If there were rhodochrosite present, I should add limestone. I must be limestone or a carbonate which on a test would show the sam qualities. I cannot answer the question with yes or no.

My investigations were concerned with the alleged anticipation of the process of the patent in suit. I did not attempt to improv any of the processes of these documents by applying knowledge o to-day. I tried to work them as well as I could with the knowledge existing at the time of their discovery, using such knowledge as a competent man might have had at the time. I made no experiments varying the quantities of oil with regard to the Froment test tube example.

156 X Q. Then I take it that you are unable to testify re-
713 garding what is the smallest and most economical quantity of oil that, in the operation of the process of the Froment British patent, will produce the phenomenon which you have described as being a magma. Is this correct?

A. That is correct. If you think it is of assistance to the Court that such an investigation should be made, I (636—558) am quite willing to do it. It did not appear to assist me in the interpretation of the invention of Froment.

From my knowledge of what has been applied as a technical process to the ore concentration industry, there is as a type the Elmore process, that is, oil buoyancy flotation by reduction of the specific gravity of a mixture of a heavy oil with minerals to such

a degree that it is lighter than water. The second process which has been found practical is the Cattermole process, the phenomenon of which is the increase of the falling power of oil agglomerated minerals to such an extent that the falling power is much greater than the falling power of the gangue. The third process is the process of the patent in suit, which, in consequence of its incredible economy, has superseded the two previous processes. My conception of a technical process is, I am speaking now of the present day, a process which is at least as economical as the agitation-froth process, whilst, at the same time, giving at least the same return. A process is one or a number of operations carried out with certain materials for the production of a certain result.

714 The process revealed in the Froment instructions differs essentially from the process as revealed in the test tube example of the Froment patent, and it differs in essential points from the process which is not described in the Froment patent but which I said might be inferred from the general description and from the claim. One of these is a desliming operation which is necessary, according to the instructions; but that is only one.

161 X Q. You refer to the Froment description as recommending that the concentrates be subjected to high pressure in a hydraulic or filter press for the recovery of (637—559) the oil. Do you think this would be a practical operation as applied to the concentrates obtained according to the process of the Froment description?

A. It is quite a feasible process and a sound one, if my recollection of the instructions is right. Froment says that it is the custom in the Latin countries, that is, Italy, Spain and France, to treat ores of a low mineral content. If you have an ore, say, containing 5 per cent of a metal, of which, however, I believe that it is scarcely ever done with certain metals such as zinc or lead, in other countries, the concentrates would contain about 15 to 16 per cent of oil, and part of that could be recovered. In many cases, perhaps a recovery could not be effected of the oil, but Froment tried in his instructions to provide for all emergencies.

715 It is well known to chemists and metallurgists that in such operations as the action of sulphuric acid on limestone, the evolution of carbonic acid gas is instantaneous if you operate in such a manner that you bring the whole of the limestone into intimate contact with the whole of the acid. Froment directs an operation lasting in all its phases for a few seconds and that clearly is advice to metallurgists that he wants practically instantaneous evolution of the carbonic acid. A longer period of agitation, in view of Froment's description and instructions in the patent, would not only be contrary to Froment's instructions, but would be utterly useless. Froment wants to make use of the carbonic acid in the nascent state and that he can do only by operating in the way as described. A longer agitation would destroy all the benefits which he derives from the gas in its nascent state. I answer, therefore, Froment directs the (638—560) short duration of his whole process because he knows that the evolution of carbonic acid from

limestone by sulphuric acid is instantaneous and he wants the us of the carbonic acid in its nascent state as, according to his r searches, this condition of the gas is highly beneficial to this proces A longer agitation would defeat this object. I did not state that short period of agitation would have the result of generating ca bonic acid more rapidly than a longer period, but I said it i advice to generate it as quickly as possible, that is, by bringin quickly all the calcite into contact with the acid.

It has been stated in this evidence that to obtain larger an firmer granules, the second agitation in the Cattermole pro-
716 cess might be varied. But that is not necessary and as I understand the patent, the patentee leaves the use of a varia-tion of the second agitation optional. I have carried the proces out in two ways; in one way, I used the same agitation for both operations; the second way I removed the baffles from the cone mixer and got a different form of agitation. The granules pro-duced by the latter experiment were larger than the ones produced by the former agitation. The determination of the agitation suit-able for the process of the patent in suit and for the process of the Cattermole patent is very simple. Cattermole requires an agita-tion which is sufficient to oil the mineral particles. The patent in suit requires an agitation which is sufficient to oil the particles and to draw in air and beat it up in a fine enough form so that it can commingle with the oiled particles. I am speaking from memory now. I believe that 500 to 600 revolutions are quite sufficient for the Cattermole process. But I believe that at least 1,200 revolu-tions per minute are necessary for the process of the patent in suit, in the (639—561) same apparatus. That is easily determined by a simple experiment. Cattermole also has much larger quantities of oil as compared with the patent in suit, which again requires less agitation.

The correct mode of estimating the degree of agitation imparted by a rotary agitator is by reference to the peripheral speed of the agitator, rather than by reference to the number of revolutions per minute, and at the same number of revolutions per minute
717 an agitator having a diameter of two feet would have twice the peripheral speed of an agitator having a diameter of one foot.

188 X Q. You have made the following statement:

"The conclusions from these experiments are that it is impossible to produce the Froment result with the proportions between ore, oil and acid, which Dr. Byrnes used in the slide machine experi-ments, and I say deliberately that it is impossible with such pro-portions to produce the Froment result of the test tube example, namely, causing the whole of the mineral to rise instantly to the top of the liquid in the form of a magma. It is obvious and self-evident from the result of these experiments that Dr. Byrnes' ex-periments cannot be in accordance with and are not the invention revealed in the Froment patent."

—. Do not the experiments performed by Dr. Byrnes, regardless of whether you consider them Froment operations or not, show that a

froth can be produced using quantities of oil largely in excess of the quantities specified in the patent in suit?

A. I have myself not made such an experiment and I am not speaking from personal experience. I am of opinion, as I stated, that if a froth is produced with quantities of oil such as are used in four of the five experiments, it must lack some of the characteristics of the agitation froth; that is, for instance, it would not show the metallic lustre and would be oily. Dr. Byrnes says he has produced a froth with a large quantity of oil. If it is produced,
718 it is not produced by the Froment process, but by the process (640—562) of the patent in suit. A froth such as can result from the quantities of oil used in four of the experiments would be valueless for the reason of its great expense.

189 X Q. Will you state whether you have determined how much wood tar oil is necessary to spread over the surface of water in a test tube of the kind which you have used in your investigations, and, if so, will you state what the quantity is?

A. I have procured a sample of wood tar oil. It did not form any layer on water. It sank to the bottom because it is specifically heavier than water. If I had been thinking carefully, I would have been able to answer the question before. In the destructive distillation of wood, a distillate is obtained which consists of three layers, the bottom layer is a wood tar oil, the medium layer is an aqueous solution of acetic acid, and the top layer is a solution of methyl, alcohol and acetone. This is a recollection of my earliest student days.

My testimony of my analysis of the oil used by Dr. Byrnes in his 4th and 5th slide machine alleged demonstrations of the Froment process, was only the statement of a fact which I had ascertained by analysis and I stated then that Dr. Byrnes' implied theories about the difference of results was not in accordance with this fact. Commercial oleic acid usually contains only as impurities palmitic and stearic acids, and the analysis is always directed to ascertaining the quantities of real oleic acid whereby also
719 the quantities of palmitic acid and stearic acid are determined. Whether this particular oil contained any other mysterious substance, I cannot tell, and whether such a mysterious substance could have any influence on (641—563) his results I am also unable to state. My analysis was only directed to ascertain the amount of oleic acid present in the two samples.

203 X Q. You state that you have proved definitely that it is impossible to produce aeration according to the test tube experiments described by Froment. Will you explain what this proof is or refer me to your testimony on the subject if you have already set it forth?

A. This statement refers to the statement of Dr. Byrnes that, "In his test tube experiment, agitation sufficient to coat the mineral particles with a thin film of the oiling agent also thoroughly aerates the mixture, the fine bubbles of air distributed throughout it, and attaching themselves to the oiled particles, acting with the chemically-evolved gas to float them."

My proof of my statement which you have quoted is in evidenc and I add further that, if Froment had had any conception of suc an aeration, he certainly would have stated it and he would n have used the generation of carbonic acid in a nascent state.

As to the amount of oil necessary to make a layer, I have mad the test with the ordinary oil, which is clearly described b
720 Froment. I have then applied the same tests with the oi which Dr. Byrnes considered to fall under this specificatio I have never made an attempt to bring before the Court a complet investigation of the layers which all oils could form on the surfac of water. I am quite willing to do so.

192 X Q. Did you ascertain how many drops of eucalyptus oi would form a layer upon water in a test tube?

A. The quantity required of eucalyptus to form a layer which could be seen was .225 cc. I give these second and third decimal as a guess. It was between .2 and .25 cc. This quantity is giving you the lowest possible (642—564) quantity which would be calle the thinnest possible layer.

At the request of defendant's counsel I have determined by ex periment that the amounts of oil necessary to form a layer upo water in such a test tube as is referred to by Froment in his Britis patent, are as given below relative to the oils there named:

Turpentine	.15 c
Mixture of 90% turpentine and 10% olive oil	.175 c
Mixture containing 75% turpentine and 25% olive oil	.225 c
Wood tar oil	.2 c
Pine oil	.25 c
Sweet pine oil or pinoline	.15 c
Mixture of pine tar oil 75% and oleic acid 25%	.2 c

721 The layer of turpentine referred to above was 15/1000 o an inch or .015 of an inch thick; the layer of 90% of tur pentine and 10% of olive oil mixture was 18/1000 of an inch o .0176 inch thick; the layer of 75% turpentine and 25% olive oi was 23/100 of an inch or .0227 inch thick; the layer of wood tar oil was 20/1000 of an inch or .0201 inch thick; the layer of pine oil was 25/1000 of an inch or .025 inch thick; and the layer of sweet pine oil or pinoline was 15/1000 of an inch or .015 inch thick.

I can only give you the number of drops by calculation. As far as I remember, the pipette which I used for dropping into the test tube gave 14 drops for .4 cc. That will give for .15 cc. about four to five drops.

The thick residuum oil used in the Elmore bulk oil flotation process is a residue of petroleum. The ordinary types are called Winter Dark oil and Summer Dark oil. (643—565)

Test tubes are made of thin glass and they withstand heat. In laboratory practice sulphuric acid is scarcely ever used for the generation of carbonic acid. Hydrochloric acid is the usual acid used for that purpose.

Redirect examination:

In producing a froth in a cone mixer I rotated the cone at a speed of 1200 revolutions per minute and also at a speed of 1600 revolutions per minute.

221 R. D. Q. In describing two tests made by you in carrying out the second process disclosed in the Everson patent, you have
722 given the amount of oil used in cubic centimeters. For the information of the Court, please compare these quantities with those specifically set forth in the Everson patent.

A. There is no ore specified in Everson's second example. I assume that she treated an ore of the kind mentioned in her patent, namely, an ore containing either gold silver or copper, which she calls "precious metals," clearly not in the ordinary chemical sense, but for the reason of their great commercial value. I could, therefore, not draw any conclusions from the second process described in Everson's patent for the ore I used. The apothecary's measure "fluid drams" was not known to me, but I satisfied myself about it, and the quantities of oil used in my two experiments are in accordance with the quantities of the example. My chief guidance, however, for the second Everson mode of operation was the fundamental condition which she specified, namely, that the mixture of oil and mineral must be lighter than the gangue. The specific weight of the mixture of oil and mineral of the first example was 1.8, the specific weight of the gangue (644—566) 2.5; the specific weight of the mixture of oil and mineral of the second example was 1.7, of the gangue 2.5.

In describing the result of the test made according to the instructions of Froment, I said that it looked like a magma, and it is true. Nevertheless, I did not intend to describe it as a magma. It is very difficult to draw the line between a thick mass of heavily oiled particles and floating oil containing mineral particles. The
723 statement which I made that the result of the test tube example is a magma consisting of oil, gas bubbles and mineral, and that the result of the process revealed by the Froment instructions is skin flotation assisted by gas bubbles, is quite correct.

223 R. D. Q. The specifications of the Froment Italian and British patents state that the oil used in the test tube example is "ordinary oil." Please note that the Italian specification is dated May 20, 1902, the British provisional specification, which repeats this statement, was filed June 4, 1902. The British complete specification which again repeats this statement, was filed March 4, 1903; also that the British complete specification states:

"This invention has reference to the concentration of metalliferous ores and earths for the purpose of separating and recovering therefrom the finely divided metal or metallic compounds, and consists of a modification of what is known as the oil process of ore concentration."

So far as possible returning to the conditions existing at the dates referred to, please state what, in your opinion, was the oil described by Froment in his patents as "ordinary oil."

A. The ordinary oil which is to be used according to the Froment

patents, can only be the oil which was used for (645—567) th
Elmore process, namely, a thick viscous mineral oil. Froment'
specification says that his process is a modification of the pro
cess which was then known as the oil process of ore con
724 centration. There was only one such process known, namely
the Elmore process, and for this process a thick viscous oi
was a necessity. The "ordinary oil" mentioned by Froment clearly
refers to such an oil. Oleic acid is not possible for Elmore's process.
The oils and oil mixtures, as to which at the request of defendant's
counsel I made layer tests, are non-viscous oils, quite unsuitable for
the Elmore process and this is equally true of the thin mineral oils
which I tested. Two of the oils, namely, wood tar oil and pine oil,
are heavier than water and cannot reduce the specific weight of
the minerals below the specific weight of water. Normally they
are at the bottom of the water.

The quantity of a heavy viscous oil, such as Elmore used, neces-
sary to form the thinnest layer, is 14.4 per cent on the ore.

224 R. D. Q. You have given figures for the smallest amount
of oil to form the thinnest possible layer in a test tube such as Fro
ment describes. What, in your opinion, is described in the Fro
ment Italian and British patents as "a thin layer" giving your an
swer, in the dimensions of the thickness of the layer?

A. The term "a thin layer" of oil, used by Froment, is not def
inite. He does not say a few drops or the thinnest possible layer
I should say that a thin layer of oil, as expressed in the Fromen
specification, does not mean a layer of less than one-eighth of an inch
thickness, but might mean more than that. (646—568)
725 225 R. D. Q. In your tests in accordance with the Fro-
ment directions or instructions, it appears that you used an
ore which had been crushed through a 60-mesh screen. I call your
attention to the specific directions as to crushing which appear in
the Froment description under the heading "B Instructions." Please
state whether or not the fineness of ore used by you was in accord-
ance with such specific instructions.

A. The standards mentioned by Froment are not known to me.
The ore which I used was crushed by step crushing in such a man-
mer that, whilst the minimum of slimes was produced, there was at
the same time a proper release of the minerals from the gangue.
It will be remembered that it is necessary to de-slime for the practice
of the Froment process revealed in the instructions.

If I had ground the ore to 80 or 100 mesh, the result of such a
grinding would have been a loss of about 50% or over 50% in
slimes. The crushed ore has to be de-slimed, and it is to the interest
of this process to avoid an excess of slime but yet to crush fine
enough to release the gangue from the minerals.

The loss in slimes would be about equal as to valuable mineral
and gangue, and therefore a loss of 50% in slimes would mean a
loss of 50% of the valuable mineral.

The following documents are offered in evidence and each en-
titled "Complainants' Exhibit," followed by the words with which
they are described in the following list:

726 British Patent 7803 of 1905;
Hoover Patent 953,746;
Hoover Patent 979,857;
Gabbett Patent 444,345; (647—569)
British Boulton & Gabbett Patent 840 of 1889;
British Patent Haynes 488 of 1860;
Hebron Patent No. 474,829;
Robson Patent 575,669;
Cattermole Patent 763,259;
Cattermole Patent 763,260;
Wolf Patent 787,814;
British Patent Chapman 17,328 of 1906;
British Patent Minerals Separation, Limited, and Nutter, 23,870 of 1910;
British Patent Nutter, Hoover and Minerals Separation, Limited, 23,949 of 1910. (648—570)

Testimony for Complainants of Charles F. Chandler.

NEW YORK, N. Y., December 9-13, 1912.

Direct examination:

I am the same Charles F. Chandler who has heretofore testified as a witness for the complainants. I have read all of the testimony in the present suit.

I will now give consideration to all documents which have been referred to as prior to the date of invention of the patent in suit, assuming that date of invention to be April 12, 1905, the date of filing, with provisional specification, of the application for British patent No. 7803, dated April 12, 1905, corresponding to the patent in suit. I will give a classified list or summary of these
727 various documents, and thereafter briefly consider them in the order of their classification.

In summarizing these documents, I have taken as my basis the summaries made by Dr. Liebmann, but in which he separated the documents put in evidence by the defendant from those put in evidence by complainants, the latter documents affording further examples of the efforts to solve the problem of ore concentration prior to the date of the invention which forms the subject matter of patent in suit. I have combined all of these documents in one classified list and have added to the list certain other documents so as to make a complete summary of the alleged prior art.

I have also given the dates of the various documents and I note that one of them, the application for the Schwarz patent No. 807,501, was filed April 19, 1905, a week subsequent to the date of the invention in suit, which I have been instructed to assume. (649—571)

Summary of the Prior Art.

I. Apparatus.

1. Campbell Morfit Extract from Treatise on Chemistry Applie to the Manufacture of Soap and Candles, of 1860.
2. Wagner, No. 373,113 of 1887.
3. Boulton, et al., and Gabbett, British No. 840 of 1889.
4. Gabbett, No. 444,345 of 1891.
5. Elmore, No. 653,340 of 1900.
728 6. Elmore, No. 692,643 of 1902.
7. Stoveken, No. 729,805 of 1903.
8. Wolf, No. 787,814 of 1905.

II. Processes for Ore Treatment without Oil.

1. Bradford, No. 345,951 of 1886.
2. Hockley, No. 466,753 of 1892.
3. Rouse, No. 469,599 of 1892.
4. Hebron and Everson, No. 471,174 of 1892.
5. Hebron, No. 474,829 of 1892.
6. Delprat, No. 735,071 of 1903.
7. Delprat, No. 768,035 of 1904.
8. Potter, No. 776,145 of 1904.

III. Processes for Ore Treatment with Oil.

(*a*) Oil and Ore mixed; Mixture Treated with Water. Hayne British No. 488 of 1860.

(*a'*) Oil and Ore Mixed; Mixture Treated with Acidulated Water

1. Everson, No. 348,157 of 1886.
2. Fryer Hill Publication of 1889.
3. Criley-Everson Publication of 1890.
4. Schwarz, No. 807,501 of 1905, Application filed April 19, 1905. (650—572)
5. Schwarz, No. 807,503 of 1905, Application filed May 27, 1904.

(a^2) Ore and Water Mixed; Mixture Treated with Oil. Robson, No. 575,669 of 1897.

(*b*) Pulp Treated with Oil; Concentrates Separated from Surface.

729 1. Elmore, No. 676,679 of 1901.
2. Elmore, No. 689,070 of 1901.
3. Glogner, No. 736,381 of 1903.
4. Good, No. 745,960 of 1903.
5. Kendall, No. 771,075 of 1904.

(*c*) Pulp Treated with Oil; Concentrates Separated from Bottom of Liquid.

1. Cattermole, No. 763,259 of 1904 (Classification).
2. Cattermole, No. 763,260 of 1904 (Emulsion).
3. Cattermole, No. 777,273 of 1904 (Granulation).

4. Cattermole, Sulman & Picard, No. 777,274 of 1904 (Soap and Granulation).

(*d*) Pulp Treated with Oil; Concentrates Floated by Introduction of Gases through Pipes, or Generation of Gases in the Mixture.

1. Froment, Italian Patent No. 63,723 of 1902.
2. Froment British Patent, No. 12,778 of 1902.
3. Froment Description and Drawings of 1903.
4. Cattermole, Sulman & Picard, No. 788,247 of 1905 (Soap and Flotation), Application filed March 29, 1904.
5. Sulman & Picard, No. 793,808 of 1905 (Bubbles), Application filed October 5, 1903.
6. Kirby, No. 809,959 of 1906, Application filed December 14, 1903.
7. Kirby, No. 838,626 of 1906, Application filed December 17, 1903. (651—573)

I. Apparatus.

1. Campbell Morfit Extract from Treatise on Chemistry Applied to the Manufacture of Soap and Candles of 1860.—This pub-
730 lication discloses a twirling fan for agitating and aerating liquid soap, so that after it is hardened it will float upon water.

This twirling fan may perhaps be well adapted to aerate soap, but it is not well adapted to agitate a gritty ore pulp.

2. Wagner Patent No. 373,113, November 15, 1887.—This patent is for a churn designed to unite together the separate particles of butter fat in the cream so as to form a solid mass of butter distinct from the buttermilk. This patent suggests an advantage from aeration during churning, but the patentee is in error in his chemistry. Aeration is not desirable in churning cream to separate the butter. This churn is not well adapted for aerating gritty ore pulp.

3 and 4. Boulton et al. and Gabbett, British Patent No. 840 of 1889, and Gabbett United States Patent No. 444,345 of 1891.—These two patents are for the same invention. The U. S. patent refers to the British patent and the corresponding patents in Belgium and France. The invention was thus patented in the United States, Great Britain, Belgium and France.

The invention consists of a mixer for liquids or semi-liquids, in which a revolving cone is arranged in a vessel, which by means of its shape or of the use of suitable baffles or other means, retards the rotation of the liquid.

The revolving cone develops centrifugal force, which tends to throw the liquid toward the larger end of the cone, thus ef-
731 fecting a circulation in the liquid which (652—574) resists the rotation of the cone, and secures a very effective agitation or mixing. This apparatus is, therefore, a "cone mixer," and is the only cone mixer I know of. This cone mixer is diagrammatically shown in the patent in suit, and also in the three Cattermole patents Nos. 763,259, 763,260 and 777,273. The Gabbett patents show the details of construction of the cone mixer.

These details of construction include stationary baffles for retarding the rotation of the liquid.

The baffle details are not shown in the four other patents, except that in Fig. 2 of the patent in suit there is an outlet pipe *a'* standing vertically in the cone mixer, which performs the function of and is, in fact, a baffle. The three Cattermole patents referred to and Fig. 1 of the patent in suit omit the baffle details, but obviously it was not necessary to repeat the details already published and explained in the Gabbett patents.

In this connection, I note that, while the earlier advertising matter of the manufacturers of the Gabbett or cone mixer gives full detail drawings including the baffles, the later advertising matter omits the detail of the baffles. The advertisement in the Journal of the Society of Chemical Industry of November 30, 1897, was undoubtedly seen by me, as I have been a subscriber to this journal for many years, ever since it was organized; in fact, at one time I was president of this society. This society is an international
732 society, has had three American presidents, and the journal has a wide international circulation.

This cone mixer is well adapted to thoroughly agitate and aerate an ore pulp, and is the apparatus disclosed in the patent in suit for effecting that part of the patented process. (653—575)

5. Elmore Patent No. 653,340 of 1900.—This patent, though put in evidence by defendant, was not explained by any of defendant's witnesses.

The general type of mixing device here disclosed has received some consideration in the testimony for complainants.

The apparatus of the patent was particularly designed to gently mix ore pulp and oil so as to avoid aeration. The patentee says:

"The ore and water and the oil which are thus mingled without being broken up so as to form a uniform mixture" (Spec. 653,340, page 1, lines 54-57).

The uniform mixture here referred to as something to be avoided, is an emulsion, such as would result from violent agitation, and which, with the large quantities of oil used in this apparatus, would defeat the object of the process in which the apparatus is to be used, to wit: the flotation of the valuable mineral of an ore by oil buoyancy.

The apparatus also includes a centrifugal separator for recovering oil from the oil-floated concentrates. From this centrifugal (*h*, Fig. 2), the separated oil is drawn up through the pipe *c* to
733 the cistern *o*, in which a partial vacuum is created so as to remove any air bubbles which may have become incorporated in the oil. Some slight aeration might result from the action of the centrifugal separator. The patentee says:

"In order to clear the oil from air-bubbles, I prefer to draw the oil up to the cistern by creating a partial vacuum in the cistern" (Spec. 653,340, page 1, lines 88-91).

It is also suggested that instead of employing centrifugal force to separate the oil from the oil-floated concentrates, the oil may be separated by first heating it (654—576) or thinning it with benzo-

line and allowing the concentrate to subside, or subjecting it to filter pressing. It is notable that the oil which is to be used is a very thick and viscous oil, compared to which oleic acid is very thin oil. The oil is described as follows:

"The thick oil which I employ is the thick tarry residue usually called 'residuum' of mineral oil after some of the more volatile constituents have been distilled off" (Spec. 653,340, page 1, lines 24-28).

This, therefore, is an apparatus for oiling a pulp with great quantities of oil so as to avoid aeration, for recovering so much of the oil as practicable from the concentrate, and for removing any bubbles of air which may possibly have become commingled with the oil.

Obviously, the apparatus is entirely unsuitable for briskly agitating and aerating an ore pulp, such as is necessary for the
734 purpose of the patent in suit.

6. Elmore Patent No. 692,643 of 1902.—This patent discloses another variety of mixing apparatus for use in the Elmore bulk oil process. This patent also was put in evidence by the defendant, but was not explained by defendant's witnesses.

The apparatus consists of a trough, through which extends a horizontal shaft carrying screw-propeller blades which act to mix the oil and pulp, and propel it toward the exit end of the apparatus. The description of the apparatus is very brief. The patentee says:

"As the liquid mineral pulp and oil are caused by the blades *c* to travel along the trough *a* they become thoroughly mixed, and the mixture issues by an opening *f* into a subsidence tank *g*" (Spec. 692,643, page 1, lines 25-29).

I also refer to the companion patent No. 689,070 for a description of the operation. Here the patentee says: (655—577)

"The liquid mineral pulp, oil and acid are caused to travel along the mixer A and become thoroughly mixed" (Spec. 689,070, page 1, lines 82-85).

The apparatus also includes a centrifugal separator for recovering the oil.

This corresponding process patent No. 689,070 merely adds to the earlier process patent the use of acid.

It clearly states the function of the oil to entrap and float the mineral. The apparatus is, therefore, designed to mix, not to
735 aerate, and is well adapted to mix a great quantity of oil with an ore pulp, and distribute the oil in contact with the valuable mineral, so that the mineral will be entrapped and floated by the oil in the next or subsidence vessel. For this purpose, the blades should be revolved at a comparatively slow speed. High speed would defeat the object of the apparatus. The apparatus is a good mixer when aeration is not desired, and when considerable quantities of oil are used. It would be an entirely inefficient device if an attempt were made to use it for the purposes of the patent in suit.

7. Stoveken Patent No. 729,805, of June 2, 1903.—Here we have a mixing device for use in a cyaniding process. Aeration is here desirable to accelerate the chemical action, but not by any means for the purpose of producing a froth. Wings *j* or baffles are pro-

vided which the patentee says will roll back the pulp to the center of the tank. This the patentee says,

"is materially advantageous, since in addition to being kept in suspension the material is worked up and down, and consequently the cyanide solution is caused to absorb the necessary oxygen and effect a rapid and complete dissolution of the gold and silver contained in the ore" (Spec. 729,805, page 3, lines 2-8). (656—578)

It is very evident that this apparatus is not designed for the high speed that would be required if an attempt were made to use
736 it for the purposes for which the agitating apparatus is used in carrying out the process of the patent in suit. Nevertheless if it were materially strengthened, it would probably do very well. It might possibly be made use of, if more rigidly and strongly built, by a metallurgist to whom the invention of the patent in suit had been disclosed as a modification of the agitating apparatus disclosed in the patent in suit.

8. Wolf Patent No. 787,814 of April 18, 1905.—Although this patent was issued six days after the date of the invention of the patent in suit which you have asked me to assume, I note that the application was filed May 22, 1903. The mixer B shown in the upper left-hand corner of the drawings is described by Mr. Sulman as the well-known Johnson mixer purchased from a London manufacturer of that name. The operation of this mixer is evidently very similar to that of the cone mixer and I should be much inclined to characterize the apparatus as representing an effort to get the effect of the cone mixer without infringing the Gabbett patent. Instead of the revolving cone, which moves the liquid up or down by centrifugal force we have a stationary cylinder, and a turbine wheel B^2 below the open end of this cylinder which operates to move the liquid up or down in the cylinder, thus affecting substantially the same circulation as in the cone mixer. Radial arms supporting the inner cylinder act as baffles to retard the movement of the liquid.

This is evidently a very good mixing apparatus, and if
737 operated at sufficiently high speed, would aerate the liquid. It was clearly not so operated in the Wolf process. (657—579) After the publication of the patent in suit, a metallurgist might well use this Johnson mixer as a modification of the mixing and agitating apparatus disclosed in the patent in suit.

This patent, although I have classified it in apparatus, discloses a process which has been referred to in the testimony as the Wolf or Scammel process. Mr. Chapman briefly describes it. Mr. Ballantyne also refers to it and its total failure.

The process is a modification of the Elmore oil flotation process, and does not in any manner resemble the process of the patent in suit. Aeration must be avoided in the mixing and separating. After the separation of the values from the gangue has been completed, the worthless residues are submitted to a treatment to recover the oil from them, this treatment consisting in blowing air through them to separate and float the oil.

General Remarks on Apparatus.—There are other documents

which disclose apparatus, but it would not be worth while to discuss them under this heading. Some apparatus is necessary to carry out any process, whether the apparatus be the simple test tube of the laboratory, or more elaborate apparatus known to the chemist or metallurgist, or special apparatus designed for the particular process. Process and apparatus are usually distinct inventions. The patent in suit is for a process. To dwell too much upon apparatus
738 would tend to confuse the issue.

II. Processes for Ore Treatment without Oil.

1. Bradford Patent No. 345,951 of July 20, 1886. This patent has been sufficiently explained. It depends upon flotability by surface tension. It lacks any positive (658—580) means for differentiating the valuable mineral from the gangue and is open to the serious objection that, in some instances, it is as apt to recover gangue as it is to recover valuable mineral, and, therefore, the recoveries are not usually concentrates.

I note from Mr. Ballantyne's deposition that the patentees of the patent in suit, Messrs. Sulman, Picard and Ballot, without knowing of the Bradford patent, worked out a similar process and gave it a thorough trial and abandoned it as worthless.

2. Hockley Patent, No. 466,753 of January 5, 1892.—This patent does not disclose a process for concentrating ores, and has really no place in the present classification. The invention consists of an apparatus for sliming ores. Its aim is to recover exceedingly finely divided metallic gold and silver, bringing them to the surface of a body of water by an up-current and retaining them there by surface tension. It is not remotely related to the invention of the patent in suit, and if of any practical value, which it does not appear to be, would never be used as an auxiliary even to the process of the
739 patent in suit, because the process of the patent in suit is unique in that it concentrates and saves all slimes. No one ever did this before in a process of ore concentration except Cattermole, and Cattermole's process, as appears in evidence, was immediately abandoned with hardly a practical trial when the invention of the patent in suit was made.

3. Rouse Patent No. 469,599 of February 23, 1892. This is another process for saving something from the slimes which are usually wasted. It is not a concentration process at all. It simply provides for carrying fine particles to (659—581) the surface and floating them there by surface tension. It is no nearer to the invention of the patent in suit than Bradford or Hockley.

No oil is used, no agitation, no acid, and the floating material is as apt to be gangue as valuable mineral.

It may be possible that a few bubbles, when they reach the surface, do not burst, but it is certainly true that most of them do when they reach the surface, and the others shortly thereafter.

4. Hebron & Everson Patent No. 471,174 of March 22, 1892.—This is the second patent of the Everson series and marks the abandonment of the use of oil to assist in floating the mineral.

It is founded upon the notion that material can be pressed into cavities between the atoms of a molecule of metalliferous matter. This is absurd.

5. Hebron Patent, No. 474,829 of May 17, 1892.—This is stated to be an improvement upon the Hebron & Everson patent
740 last considered, the improvement consisting in heating an ore so as to drive the air out of its alleged pores between the atoms of the molecules and forcing in buoyant material, by pressure, and then aerating the surface. After this has been done, the effort is made to float it.

This is the last patent of the Everson series. Carrie J. Everson was one of the patentees as the assignee of a part interest. It marks a said ending of an enterprise which started with real genius.

Carrie J. Everson discovered the great assistance to ore separation by oil which was effected by the use of an acid, but she worked this out in an utterly impracticable bulk-oil process. The cost of oil was prohibitive. Instead of discovering the possibility of the utilization of a (660—582) minute quantity of oil, she abandoned oil, and the enterprise ended in these two ridiculous patents founded upon altogether untenable theories of molecular construction.

6 and 7. Delprat Patents No. 735,071 of August 4, 1903, and No. 768,035 of August 23, 1904.

8. Potter Patent No. 766,145 of November 29, 1904.—These three patents will all be considered together. They disclose processes for generating gases in an ore pulp by the action of acids, nitric or sulphuric. The gas utilized is probably carbonic acid gas, although Delprat, in his second patent, and Potter speak of sulphuretted hydrogen. The gas is supposed to select the metallic particles
741 and float them to the surface, producing a tender float. This Dr. Byrnes illustrates in his illustrative Experiment 4 of his test tube experiments said to be made in connection with the Froment patent. No oil is used and there is no aeration by agitation.

General Remarks on Processes not Using Oil.—These proposed processes, in which no oil was used, are of interest as showing the activity of inventors during a period of twenty years from 1885 to 1905. In considering the processes which used oil, it will be found that the Everson patent, the application for which was filed August 29, 1885, and which uses a great amount of oil, and which is altogether out of question because it uses so much oil, was at the beginning of this period. The process of the patent in suit was invented, according to the date that I am to assume, on April 12, 1905. The eight patents above explained appeared successively at different times during this interval. They may all be taken as efforts to save the expense of oil. Two of them were further developments of Everson, but with the abandonment of oil. Not one of them discloses the process (661—583) of the patent in suit, and they do not lead to or suggest the process of the patent in suit. They are evidence of the desirability of the object which was attained by the process of the patent in suit, and they show that many other inventors worked with the same object, but utterly failed and missed the invention.

742 III. Processes for Ore Treatment with Oil.

(*a*) Oil and Ore Mixed; Mixture Treated With Water. Haynes British Patent No. 488 of 1860.—This patent discloses a process of ore separation in which powdered ore is mixed with an agent composed of substances not soluble in water, one class of these substances being fatty or oleaginous matters. It may be said generally that he describes the making of a mixture which would be a stiff paste and then triturating in water to wash out the gangue. A procedure is also described for removing the agent from the metal.

It should be noted that for sulphurets, for which the patent in suit is especially adapted, Haynes does not use any oily or fatty matter in conjunction with his bituminous combination of coal tar, resin, etc.; and further that his proportions of bituminous agent are very large, from one to five of ore (20 per cent), to one to nine of ore (11 per cent). The name "sulphurets" is the old name for sulphides.

(*a'*) Oil and Ore Mixed: Mixture Treated With Acidulated Water.—1. Everson Patent No. 348,157 of August 24, 1886.—This patent discloses two methods of treatment. The first is altogether impracticable and has not been commented upon by Dr. Byrnes.

A compound is made of sulphuric acid, cotton-seed oil and water and mixed with the ore so as to produce a stiff mass or pudding. I have tried this with indifferent results. (662—584)

743 The second method I have also tried. This Dr. Byrnes says he has tried, but the procedure which he adopted is not warranted by the Everson disclosures. His test resembles the Everson procedure only in the quantities of materials used. In all other particulars he uses the knowledge of to-day and by repeated agitation in the slide machine, without oil additions, and by removing his floating material as fast as it is formed, he reduced the amount of oil in each successive treatment, and, as there were nine successive treatments, he probably had removed the greater part of his oil before the last treatment.

I carried out the instructions of the Everson patent as to the second method of treatment described therein in the following manner: I took 16 oz. of defendant's ore, crushed so as to pass through an 80 mesh sieve, and 24 drams of petroleum, and mixed the same thoroughly in a porcelain mortar. The result was a damp sand resembling molding sand. I then prepared some acidulated water by adding 8 drams of oil of vitriol to four gallons of water, the above being the proportions suggested in the Everson specification. I then put the ore, mixed with petroleum, in a slide machine with 1700 cc. of the acid water and agitated thoroughly for two minutes. On stopping the agitation an oil mess appeared on the top of the water in the machine.

I then ran the contents of the slide machine, while the agitation was continued, into a washing out vessel, in which there was an upward current of acidulated water with constant overflow.

744 The result was concentrates 119 grams, tailings 255 grams. There was little difference between them. There seemed to be little more valuable mineral in the concentrates than there was in

the tailings. Some of the material remained behind in the slide machine. The (663—585) separation was a complete failure.

This Everson patent is of interest as containing the first disclosure of the use of an acid in connection with oil to prevent the oil from attaching itself to the gangue. This was an important step forward in the art, but the amount of oil used in the Everson patent was prohibitive. Apparently an attempt was made to use this process with silver and gold ores, but even with these ores the process appears to have been a failure, as it has only been heard of in connection with two published experiments, which I shall now consider.

2. Fryer Hill Publication of 1889.—This article in the "Daily Herald Democrat," of Leadville, Colorado, dated October 30, 1889, describes an effort to use a process resembling the Everson process on silver ores. Petroleum is the oil used and the water is acidulated with sulphuric acid. Steam is used to heat the mixture and in this respect the Everson process is improved upon. An up-current in the agitator causes the mineral-charged oil to be carried to the surface, where it is trapped by closing two semi-circular doors beneath it, and then the mineral-laden oil is removed to settling barrels. The newspaper report is quite enthusiastic and says that there are thousands of tons of this ore awaiting this treatment. Apparently
745 nothing more was heard of this effort to use the Everson process with silver ores.

3. Criley-Everson Publication of 1890.—This article in the Engineering & Mining Journal of November 15, 1890, describes what appears to be a laboratory test of the Everson process with a gold ore of the Eureka & Excelsior Gold Mining Company. A black thick oil and acidulated water heated nearly to boiling are described as having been used. (664—586) The description reads like that of an Elmore bulk oil flotation experiment.

This is the last that was heard of the Everson process as an oil ore concentration process. In the subsequent patents of the Everson series no oil is used. These are the Hebron & Everson patent, No. 471,174 of 1892 and the Hebron patent issued to Carrie J. Everson as one of the assignees, No. 474,829 of 1892. I considered these two patents in their proper place and commented there upon the fact that they indicated that the great expense of the large quantities of oil used in the Everson process was overcome by abandoning altogether the use of oil.

4 and 5. Schwarz Patents Nos. 807,501 and 807,503 of December 19, 1905.—The application for the first of these patents was filed April 19, 1905, and it is, therefore, too late to be considered as a prior document to the application for the British patent corresponding to the patent in suit, filed April 12, 1905. This document is, therefore, very nearly contemporaneous with the first official document disclosing the invention of the patent in suit. It dis-
746 closes what is clearly a bulk oil flotation process and the injection of air or gas to give a certain sponginess to the mass of oil carrying the mineral so as to increase the floating power of this mass of oil and mineral.

The second Schwarz patent, No. 807,503, was issued on an applica-

tion filed May 27, 1904, and is, therefore, to be considered as a prior document. This also is a bulk oil flotation process, in which the mineral is entrapped in and floated by the oil. Oil is used in sufficient quantities to make with the ore a thick pasty mass, which is first mixed without any water and then mixed with water.

"The mass is then allowed to subside, when the selective material with the entrapped metallic (665—587) constituents of the ore will rise to the top and may be removed in any suitable manner, as by floating over the top of the vessel" (Spec. 807,503, page 1, lines 65-69).

The selective material is oil. During the first mixing, air or gas is blown in to give the thick pasty mass a certain amount of sponginess. After the admission of water the blowing of air, steam or gas may be continued.

Dr. Byrnes described an alleged Schwarz test, but as he only used sufficient oil to give the mixture of oil and ore the consistency of molding sand, which is a slightly damp sand, it is quite certain that he did not follow the directions of Schwarz and did not produce a thick pasty mass of such consistency that it would acquire sponginess when air was blown in it.

I carried out this Schwarz process in accordance with the
747 directions of the patent in a test which I will now describe.

As Schwarz states in the second patent that he prefers crude petroleum or any of its products, to which is added about 9 to 10 per cent by weight of paraffin, I prepared the following mixture: 90 grams of crude petroleum, in which I dissolved 10 grams of paraffin wax. I then weighed out 300 grams of defendant's ore, crushed so as to pass through an 80 mesh sieve, and mixed it with the petroleum and paraffin. The whole formed a thick paste. This I put into the slide machine, pumped air in it at the bottom and kept the agitator going slowly. There was not enough material to keep the agitator covered. The material was so thick that it piled up at the sides and corners, and the air, which was blown in underneath it through a perforated coil, made channels at one or more points and then blew through these channels without aerating the mixture. I, therefore, decided that a greater proportion of (666—588) oil was necessary, and material enough to well cover the agitator, so I added 300 grams additional ore and 200 grams of the mixture of paraffin and petroleum, the result being 600 grams of ore and 300 grams of the mixture of paraffin and petroleum, the latter amounting to 50% of the weight of the ore. I then continued the agitation and the injection of air.

I next injected water under pressure, continuing the agitation and adding 2 cc. of sulphuric acid, and also continuing the injection of
air. There was produced a floating mass on the top of the
748 contents of the machine about one-half an inch thick, mainly
oil, with some air bubbles and some mineral but with considerable gangue. On examining the tailings I found them full of oil and other minerals. The process was a complete failure.

Schwarz got very little further than Elmore in oil economy. The

process does not appear to be of any practical value whatever and is very far removed from the process of the patent in suit.

(a^2) Ore and Water Mixed; Mixture Treated With Oil.—Robson Patent No. 575,669 of January 19, 1891.—The process here disclosed is unique, in that the ore is brought into a moist condition by the admixture therewith of a small quantity of water, from 25 to 35 per cent and an attempt is made to wash out the mineral with oil in a mixing vessel in which the "mud or mass" is to be brought into intimate contact with the oily liquid. The quantity of oil used in such a process would, of course, be enormous and prohibitory. (667—589)

(b) Pulp Treated With Oil; Concentrates Separated from Surface.—1 and 2. Elmore Patents No. 676,679, of June 18, 1901, and No. 689,070 of December 17, 1901.—The second of these patents differs from the first only in that acid is added to the ore pulp.

Both are bulk oil flotation processes in which a great quantity of oil is used, which acts to entrap the mineral and float it to the surface by reason of the fact that the specific gravity of the mixture of oil and mineral is less than that of water.

749 Brisk agitation must be avoided because it would tend to make a uniform mixture or emulsion, which would prevent the separation. An effort is made to save some of the oil by treatment in a centrifugal machine or by a filter press, and the recovered oil is treated to an air withdrawing operation, so as to remove any air bubbles that may possibly have gotten into the oil.

Dr. Byrnes very properly says of the four Elmore patents, two for apparatus and two for processes, all of which I have considered, that they

"relate to the flotation of mineral by oil per se rather than gas."

And also that

"The flotation processes described therein do not rely on aeration or the evolution of a gas."

It is in evidence that these Elmore processes were tried in practice and long since abandoned, and this I can well understand, since the loss of oil, with all the efforts made to recover it, would be very much greater than the amount of oil used in the process of the patent in suit.

I have made several tests of the Elmore process. The (668—590) amount of oil with Broken Hill ore required for carrying on the process would be about 6,000 lbs. of oil for a short ton of ore. This is not all used at once, and a reasonable way of carrying out the process would be to use 100% of oil at a time as described by Mr. Chapman.

I carried this out in practice and measured the thickness of the oil layer which constituted only 100% of the ore. This layer

750 was one inch in thickness in a large test tube, and a trifle under one inch in thickness, in fact, 15/16ths of an inch, in a glass cylinder about three inches in diameter.

3. Glogner Patent No. 736,381 of August 18, 1903. This is the first of the graphite patents and describes a bulk oil flotation process

for separating graphite from gangue. The oil used is petroleum and the quantity used is about half that of the graphite contained in the ore. The mixing vessels are suspended pots, "preferably operated by human force" at the rate of thirty shocks per minute, or one every two seconds. Dr. Byrnes theorized on this process, but apparently has not tried it in practice. He says that the agitation of these swinging vessels will intermingle with the pulp a large amount of air,

"just as an ocean wave entangles air and forms a floating froth or foam."

Again he says:

"Glogner 736,381 illustrates an oscillating, agitating vessel, in which the mixture of ore pulp and water is thrown violently against one end of the vessel, the wave falling back through the air, thus imitating aeration and frothing produced by an ocean wave."

I tried this out in practice. Not a particle of froth or foam was formed. The graphite floated to the surface entrapped in an oil layer, which was remarkably smooth. Instead, however, of using a swinging vessel, I (669—591) used a bottle. Mr. A. Howard
751 Higgins supplied the human force, and very vigorously shook the bottle at the rate of thirty sharp shocks per minute.

4. Good Patent No. 745,960 of December 1, 1903.—This is really an apparatus patent for treating graphite in a bulk oil process. The apparatus and its operations have been fully described by Dr. Liebmann and I shall not repeat his description, as the patent discloses nothing having any relation whatever to the process of the patent in suit.

5. Kendall Patent No. 771,075 of September 27, 1904.—This is the third and last of the graphite patents. It describes a process for treating graphite or graphite waste with kerosene oil or "paraffin oil," as it is called in England,

"which adheres to and by reason of its levity separates the graphitic substances" (Spec. 771,075, page 1, lines 14-16).

This is clearly a bulk oil process in which the mixture of oil and graphite must be light enough to float on the surface of the water. This is true of the three graphite processes which I have considered and they are no nearer to the process of the patent in suit than is the Elmore bulk oil buoyancy process.

(c) Pulp Treated with Oil; Concentrates Separated from Bottom of Liquid.—1. Cattermole Patent No. 763,259 of June 21, 1904.—This is the Cattermole classification process for separating granules of mixed sulphides obtained by the Cattermole process or breaking down of granules. This is really a supplement to the Cattermole process, and not in itself an ore concentrating process.

752 2. Cattermole Patent No. 763,260 of June 21, 1904.—(670—592) This is the emulsion patent, and is a division of the application for the Cattermole granulation patent next to be considered, and everything described in it is also described in that patent, which I will now consider.

3. Cattermole Patent No. 777,273 of December 13, 1904.—This is the granulation patent and constitutes the next real step forward in the art after the Elmore patents.

A great reduction is made in oil quantities from those used in the Elmore process. Instead of 6,000 lbs. of oil to the ton of ore, we have a recommended proportion of from four to six per cent of the weight of the metalliferous mineral present in the ore, which, with Broken Hill crude ore, which contains about 50% of mineral, would be 2 to 3 per cent on the ore. With Broken Hill tailings, containing about 30% of mineral, this recommended percentage would be 1.2 to 1.8 per cent on the tailings, which in this instance would be the ore.

It is very evident from this patent that the process is not adapted for use with lean ores since there is a caution to increase the amount of mineral if there is but little mineral present in the ore.

The fundamental idea of this patent is the production of agglomerated masses having sufficient falling power in water to enable the gangue to be carried upward away from the mineral by an up-current of water, the mineral falling to the bottom of the up-current vessel.

753 No amount of juggling with figures can make this a flotation process. Dr. Byrnes appears to have finally convinced himself that the process of this Cattermole patent

"is one of oil-gas flotation."

This conclusion is so greatly at variance with the disclosures (671—593) of the Cattermole granulation patent that it seems incomprehensible that it could have been reached even as a result of pure mathematics dissociated from actual tests.

I have tested this Cattermole process and have obtained results such as this patent describes. The process is extremely interesting, and if the process of the patent in suit had never been invented, it might have been useful to-day.

It is in evidence, however, that it was immediately displaced by the process of the patent in suit after a short trial, in which the oil consumption alarmed the mine owners, and efforts were made to reduce the oil consumption, as testified to by Mr. Chapman.

4. Cattermole, Sulman & Picard Patent No. 777,274, of December 13, 1904.—This is the first of the so-called soap patents, and is known as the Soap and Granulation patent. It discloses granulation according to the Cattermole process with the use of soap, which is a compound of oleic acid and soda, and which is decomposed into oleic acid and soluble sodium sulphate by sulphuric acid. The process described is the granulation process with this modification as to the oily material and the method of obtaining it.

754

I note that Dr. Byrnes succeeded in convincing himself by mathematical computation that this patent was, like the Cattermole patent No. 777,273, one of oil-gas flotation. I quote from the patent as follows:

"This process may conveniently be rendered continuous by feeding ore-pulp, soap solution and mineral acid continuously into one or more agitating vessels and discharging the products of agitation

into an up-current separator, which allows the metalliferous granules to fall to the bottom of the vessel, while the particles of gangue are carried away by an upward stream" (Spec. 777,274, page 1, lines 36-74). (672—594)

It is very evident that Dr. Byrnes had forgotten the language employed by the patentees when he reached his remarkable conclusion.

(*d*) Pulp Treated with Oil; Concentration Floated by Introduction of Gases Through Pipes, or Generation of Gases in the Mixture.—1. Froment Italian Patent No. 63,723 of 1902.—The specification of this patent is dated May 20, 1902. The specification starts with a statement of four phenomena studied by the inventor which are stated to have served as a basis of the process which forms the subject of the invention. The four phenomena are then briefly stated and are followed by a statement of a test-tube example, in which proportions are given or indicated and agitation for a
755 period of a second is directed. This test-tube example, when performed as directed, results in the flotation of a magma or paste of oil and mineral with gas bubbles in it. After the description of the test-tube test, the patentee says:

"Such is the principle."

Then follows, as example 1, a description of an ore and a statement that only a few seconds are necessary for completely separating the sulphide of one of the metals from the rest of the gangue. This means, of course, the complete operation of agitation and subsidence. Then follows, as Example 2, a brief description of another ore and a statement that it had been treated in the same manner and with the same success.

It will be noted that we have here no description of any process except a process carried on in the simplest laboratory apparatus, to wit: a test tube. That process appears to be workable in that apparatus. I have tried it and have obtained fair separation of the metals from the (673—595) gangue. Possibly if I had the same ore Froment had, I might have come nearer to the complete separation which he describes.

I have said the proportions are either given or indicated. The weight of the ore, 10 grams, of the limestone, one gram, and the water 30 grams, are precisely stated. The amount of sulphuric acid is stated as a few drops. This is indefinite. Certainly the sulphuric acid has to be used with caution, as it effects a gas generation reaction, which, if too violent will expel the contents of the test tube, but the caution of the specification is against excess of lime-
756 stone, not excess of sulphuric acid, and one gram of limestone would require one gram of sulphuric acid, concentrated, for its complete decomposition. This would be about 26 drops from a bottle, or 32 drops from a pipette with a small opening, or 23 drops from a pipette with a large opening.

The quantity of oil is specified as a thin layer. The kind of oil is specified as ordinary oil. The ordinary oil of the oil process of ore concentration known at that time, to wit: the Elmore bulk oil buoyancy flotation process, was thick residuum oil. The layer in a test tube of this Elmore process, using the minimum quantity of

oil for such tests, is at least an inch thick. It appears in the testimony of Mr. Ballantyne that this Elmore process was in use at the mines in Traversella, Italy, where Froment was engineer. Therefore, in my opinion, it is a reasonable interpretation of the meaning of the statement "a thin layer of ordinary oil," that a layer from an eighth of an inch to a quarter of an inch in thickness of thick residuum oil is described.

The thinnest possible layer of this thick residuum oil requires a quantity of oil 11.7 per cent of the ore, (674—596) 42 drops, equivalent to 1.3 cc., but Froment evidently did not mean to describe the thinnest possible layer, but only a layer which would be thin as comparable with the inch thick layer of Elmore.

The time of agitation is definitely stated. The mixture is to be abitated for a second, as the reaction generating the gas is an instantaneous reaction and the gas will escape if the agitation
757 continued for anything more than a brief space. This explicit direction to agitate for just one second is reasonable and what I would expect.

I have obtained a floating magma containing a fair proportion of the mineral by agitation for one second and have then destroyed or greatly diminished the float by agitation for a few seconds more. Froment had but one idea, and that was to float the mineral by carbonic acid generated chemically, and he has disclosed in this patent a very interesting and fairly effective test-tube operation, which, if carried out in accordance with his directions, is successful, but which, with a too long agitation, fails because of the escape of the generated and liberated gas.

As I said, the only procedure described in the patent is the test-tube operation. It is rather surprising to read at the end of the specification that there are several distinct, but connected operations in the practical working of the process. The only working that has been described is a test-tube operation, which is certainly not a practical working. These operations of a practical working process which have not been described are then set forth and I will enumerate them with exact quotations:

(1) "The formation of the spherules and their separation from the gangue."

(2) "Then separation of the concentrates and the oil and recovery of this latter for re-entrance into the circuit of operations." (675—597)

The part which I have numbered (2) has not been heretofore described, but it was a well-known step in the Elmore process
758 and probably the inventor deemed it unnecessary to describe it. He says:

"The products of the concentration form oil cakes."

This indicates that the oil is recovered in a filter press, as suggested in the Elmore patent No. 676,679. As such procedure does not recover all the oil, his statement is quite accurate. His concentrate would be in the form of oil cakes, the particles of the concentrate adhering together by reason of the oil left in contact with them.

The claim gives a little further description of the oil. It is stated to be

"an oily fat body,"

and it is stated not to be

"an oily body derived from bitumens, tar, naphtha, etc."

This excludes wood tar, coal tar and all their derivatives, such for example as pine-oil, sweet pine oil and wood tar oil. It also excludes all essential oils, such as eucalyptus and turpentine, since they are not fatty oils. It excludes the lighter distillates of petroleum, naphtha, etc., but thereby includes thick residuum oil. Whatever he had in his mind, he described a thick oil and as petroleum residuum was then used in the art as the ordinary oil for concentrating ores, I think it is evident that he meant to describe this petroleum residuum.

2. Froment British Patent No. 12,778 of 1902.—The date of the application, with the provisional specification, of this patent,
759 is June 4, 1902, which is about two weeks later than the date of the Italian specification. (676—598) The patent was applied for and issued to Henry Harris Lake, of the well-known firm of Haseltine, Lake & Company, London, patent agents, as a communication from Froment. The provisional specification is almost an exact literal translation of the Italian specification, except for the absence of the claim, and provisional specifications do not contain claims. The slight changes are such as one would expect from a translator who is a British patent agent. The statement as to the period of agitation, which in the Italian specification is "a second" appears in the British specifications as "a brief space."

The statement of the Italian specification that the products of the concentration form oil cakes, becomes in the British specification that the products of concentration form cakes. Other slight verbal changes are unimportant.

The British complete specification, which appears to have been filed March 4, 1903, repeats the provisional specification except for the opening statement that the invention is now "particularly described and ascertained" and the reference to what is known as the oil process of ore concentration, of which this invention is stated to be a modification, and except also for the claim at the end of the British complete specification, which is quite different from the Italian claim and suggests a process in steps: (1) mixing the finely powdered ore with water; (2) adding a suitable oil; and (3)
760 then liberating a gas in the mixture. There is no reference to squeezing out the oil from the concentrates in this claim and very properly, because this was old in what was then known as the oil process off ore concentration, to wit: the Elmore bulk oil buoyancy flotation process. (677—599)

The only definite disclosure of either of these patents is of a test-tube operation. The remainder of the patents is theory and speculation. Each patent itself describes the only definite disclosure in it as an example of the principle, and the Froment patents are, in

fact, patents for a principle, not worked out into any practical o useful process.

I have made a number of test-tube tests according to the test-tub operations described in the Froment patents, and departing from i in the use of other oils which were used by Dr. Byrnes in his test alleged to have been according to Froment, but substantially differ ent from Froment in every instance. Two of my tests are as fol lows:

Experiment 1.—I took 10 grams of defendant's ore, crushed t pass through an 80-mesh sieve. To this I added one gram of pul verized calcite (carbonate of lime), 30 cc. of water. I agitated them sufficiently to moisten the ore and the calcite and mix them together. I then put five drops of oil of vitriol into the tube and a layer of Winter Dark oil, just sufficient to cover the surface of the water, which amounted to 1.3 cc. I then gave it five shakes, which occu-
pied one second, and on allowing it to stand for a moment, a magma
rose to the surface which measured a vertical inch in thick-
761 ness. The tailings at the bottom of the tube were fairly
clean. I then shook the test tube another second. Th magma diminished and measured less than one-half an inch, an the tailings appeared darker from the subsidence of some of th metallic particles. I then shook it another second, and the magm diminished to one-fourth inch. I then shook it another second an the magma diminished still further and the tailings became quit dark. I then shook it another second, and the magma remaine about the same, but was nearly all oil. (678—600)

Experiment 2.—I took the same ore that I used in Experiment 1 10 grams, limestone 1 gram, water 30 cc., agitated sufficiently to we the ore and limestone; then added 1.6 cc. of oleic acid comparatively pure, 5 drops of oil of vitriol, agitated for one second. The resul was a good half inch of magma. I shook it five seconds more and nearly all the magma disappeared, the mineral matter going to the bottom. Nothing on the top but a few clean bubbles and a little mineral floating by surface tension.

The following experiments are Dr. Byrnes' slide machine tests translated back to the Froment test tube tests.

Experiment 3.—I took 10 grams of defendant's ore, same as before, 30 cc. of water, one drop cotton-seed oil, and 7.4 cc. of 1/10th normal sulphuric acid, equivalent to 0.036 gram of sulphuric acid; shook for one second; result, no separation of mineral and no
flotation. Shook the tube for 8 seconds longer; the result
762 was a little collection of bubbles on top containing a slight
amount of unseparated slimes. There was no separation of minerals from the gangue and the experiment was an absolute fail-ure. This was a translation of Dr. Byrnes' first experiment in the slide machine.

Experiment 4.—Experiment repeated, substituting 0.4 cc. of cot-ton-seed oil for the one drop of cotton-seed oil in the previous experi-ment; everything else the same. Shook for one second, practically no separation of mineral from gangue; some bubbles on top; n

mineral, only a little unseparated ore. This is Dr. Byrnes' second experiment, translated from the slide machine to the test tube.

Experiment 5.—This was the same as Experiment 4, with the substitution of 0.4 cc. of olive oil for the (679—601) cotton-seed oil of the previous experiment. Shook one second, no mineral separation, few bubbles on top with a little unseparated ore.

Experiment 6.—Experiment as before except 0.4 cc. of defendant's red oil was used, previously warmed slightly to make it thin, as the room was cold; shook for one second; no mineral separation; few bubbles on top quite clean, and very little unseparated ore.

Experiment 7.—Same as before, with the substitution of Hegeman's comparatively pure oleic acid, 0.2 cc., half as much as before. Result the same as in the other experiment.

I might note that the quantity of oil employed in all these
763 experiments was only a fraction of "a layer" as called for in the Froment patents, and, further, that no limestone was added in these experiments, because Dr. Byrnes used none and, consequently, there was practically no carbonic acid gas produced, as the small amount of rhodochrosite in the ore would not be acted upon by the very dilute sulphuric acid present and could not furnish any material quantity of carbonic acid gas.

I then repeated these experiments employing the same ore which I previously de-slimed by means of water, washing out the slime by successive stirrings with water. I took 100 grams of the ore for this purpose; after washing out the slime, I dried the residuum of de-slimed ore and it weighed 64 grams, thus representing 64% of the original ore.

Experiment 8.—De-slimed ore, a repetition of my Experiment 3. A small quantity of mineral came to the surface around the edge, not enough to form a layer, and this dropped quickly to the bottom, shook for only one second. (680—602)

Experiment 9.—This is a repetition of my Experiment 4 with the de-slimed ore; shook for one second; some floating material, heavy, and tended to drop back. Shook another second; a little larger amount of float. Experiment not a success, as there was no substantial separation of mineral from gangue.

Experiment 10 was a repetition of my Experiment 5 with the de-slimed ore. The result was the same as in Experiment 9.

Experiment 11.—This is a repetition of my Experiment 6, with
the de-slimed ore; shook one second; layer of bubbles; practi-
764 cally no mineral; bubbles quickly burst; most of the mineral dropped.

Experiment 12.—A repetition of my Experiment 7, on de-slimed ore, using 0.2 cc. of Hegeman's comparatively pure oleic acid; shook one second; very little float; particles sink and rise.

Not one of these experiments from 3 to 12 was a success.

I then repeated the same experiments, using Defendant's Feed to Flotation Plant, used by Dr. Byrnes, which had been exposed to air and dampness since the taking of Dr. Byrnes' testimony, and had suffered oxidation to a greater or less extent.

Experiment 13 was a repetition of Experiment 8. The result was very little float, which settled at once to the bottom.

Experiment 14 was a repetition of Experiment 9. There was quite a layer. The particles, however, were heavy and tended to go down; not a good separation.

Experiment 15 was a repetition of Experiment 10. The results were substantially identical with those of Experiment (681—603) 14; not a good separation.

Experiment 16 was a repetition of Experiment 11. There was very little float, which settled at once to the bottom; not a good separation.

Experiment 17 was a repetition of Experiment 12. There was quite a layer; the particles were heavy and tended to go down; not a good separation.

3. Froment Description and Drawings of 1903.—Here we
765 have for the first time a description by Froment of a process and apparatus capable of dealing with ore in practical quantities. He first directs crushing the ore so as to arrive at a disintegration of the particles without rendering it impalpable. The sieves are not described according to any standard known to me, or which I could ascertain. A wet process is recommended, as is undoubtedly best in practical operations at a mine or mill, and de-sliming is directed. He truthfully says that the fine slime eliminated by de-sliming could not be treated by any hitherto known method.

The de-slimed ore is fed into the mixing apparatus, which he calls a centrifugal mixing apparatus containing two stirring devices worked in opposite directions and making about 300 revolutions per minute.

Then the mixer is charged with ore and water, about 1% of carbonate of lime, maximum 2% in difficult cases, and about 1 to 1½ per cent of mineral engine oil are added. The mixing apparatus is then allowed to work for ten minutes, the chief point being that all the sulphide grains shall come into thorough contact with the oil.

This is a clear statement of the necessity of thoroughly mixing the oil and the ore.

I have repeated this operation in "Complainants' Exhibit, (682—604) Reproduction of Froment Mixer," with a richer ore, and therefore with more limestone and oil, and have mixed the ore, limestone and oil, and did not obtain a particle of mineral froth or any
766 appreciable mineral float, and have also repeated it in a cone-mixer, and have even repeated it in the slide machine. The result was always the same. The substances were mixed together and the oiled ore went to the bottom. This operation is, therefore, purely a mixing operation.

The process as thus described is for a lean ore. If the ore contained more than 5% of metallic matter, Froment says it would be necessary to use more oil, and recommends 2% for ore containing up to 15% of metal, indicating this as the upper limit for copper ores in the Latin countries, while for lead ores, which are richer, Froment recommends 2½% of oil for an ore containing 30% of metal, 3% of oil for 40% of metal, and 3½% of oil for 50% of metal. He says it seems reasonable to assume that the proportion of carbonate of lime will follow practically the same rule. This is, however, evidently a

mere assumption. After the ore, oil and limestone have been mixed, the mixture is discharged into Froment's second apparatus, described as a vat with a coil, having a rake-like stirring device, to be operated at 10 to 12 revolutions per minute. Here sulphuric acid is added through a perforated coiled pipe at the bottom, and produces the chemical reaction which is the characteristic feature of the Froment invention. The greased sulphides are said to rise to the surface carried by gas bubbles. The rake, although moving slowly, disturbs this surface and it would be reasonable to expect that much of the
mineral would sink again and that the gas bubbles would
767 (683—605) escape, leaving some mineral floating by surface
tension. As a matter of fact, I tried this apparatus, "Complainants' Exhibit, Reproduction of Froment Vat with Coil," and it proved to be a very poor stirring device, merely forming grooves in the oiled ore at the bottom of the vessel, and I got hardly any float.

Froment says that the stirring rake is to prevent the ore from collecting at the bottom of the vessel in too compact a mass. If the stirrer were more efficient, it would do this. He admits that a small proportion of the greased sulphide which had been carried to the surface by the gas bubbles would fall back and get mixed with the gangue, and he provides for screening the residues from the bottom of this vessel. This part of the apparatus does not appear to be of any importance and I shall not describe it.

The closing statement is that the concentrated ore may be treated in a hydraulic press or filter press to recover a very large proportion of the oil.

The test of "Complainants' Exhibit, Reproduction of Froment Mixer" and "Complainants' Exhibit, Reproduction of Froment Vat with Coil" in accordance with Froment's instructions, was made in the presence of Dr. Adolf Liebmann and myself, as well as two following tests, one with the cone-mixer as the mixing apparatus and an efficient hand stirring in a shallow vessel, and the other with a modern slide machine as a mixing apparatus and the same efficient
stirring. These tests are fully described by Dr. Liebmann and
768 I will not, therefore, repeat this description. The hand
stirring was with a glass rod and was carefully done so as to but slightly disturb the surface of the liquid, and the oily mineral float obtained was, therefore, not broken up as it would have been by the revolving rake in (684—606) the Froment vat with the coil. Therefore, the float obtained by the hand stirring retained its gas bubbles to a considerable extent and was a somewhat pasty mass of oil and mineral with gas bubbles in it. I should say that with the Froment apparatus we obtained a very small amount of surface tension flotation, while in the other two experiments the floating mass was very much like the magma of the Froment test-tube test.

The Froment description and drawings describe a process and apparatus and show an apparatus which discloses a development of the undeveloped ideas of the Froment patents. They provide for effective oiling of the ore with a quantity of oil much smaller than is necessary in the agitation for one second exactly directed in the Italian patent, and substantially directed in the British patent, but the Froment patents and Froment's later disclosures in his directions

and drawings fail utterly from the standpoint of practicability. Th minerals consumed oil, limestone and sulphuric acid, the latter tw in such quantities as to generate the gas necessary for the flotatio of the ore, cause a total cost which is prohibitive, even if the proces could have been compelled to work successfully in practice. Th cost of the oil alone is prohibitive. For Broken Hill ores
769 the oil consumption would be 2½% or 50 lbs. to the shor ton.

I cannot seriously consider these Froment disclosures as a di closure of the process of the patent in suit. The process or processe are so substantially different in all essential particulars that they ar not comparable.

4. Cattermole, Sulman & Picard, No. 788,247, Patented April 25, 1905, Application Filed March 29, 1904.—This is the second of the Soap patents, and is known as the Soap (685—607) and Flotation Patent. It is a companion patent to No. 777,274, the Soap and Granulation Patent. It discloses the use of the soap reaction in the separation of minerals in connection with practically all processe then known in which it appears to be utilizable, except in the Granu lation process covered in the companion patent No. 777,274.

It describes the removal of the coated mineral particles from th gangue by generating gaseous bubbles in the mixture, or by the us of buoyant material, such as greased wood and sawdust.

It is a broad patent for the soap reaction in the concentration o ores, and also specifically for the use of this soap reaction in the flota tion processes as then known employing a smaller amount of oil than was necessary to float the mineral by buoyancy. It does not disclose the process of the patent in suit or anything like it.

5. Sulman & Picard Patent No. 793,808, Patented July 4, 1905, Application Filed October 5, 1903.—This is known as the
770 Bubbles patent, although the name is not descriptive, since the patent describes processes in which bubbles are not util ized, as well as those attempting to use gas or air bubbles.

In the apparatus shown in Figure 1, the effort is made to utilize air bubbles to float oiled minerals to the surface in a body of liquid which is maintained in a turbulent condition by a coiled pipe rotat ing at the bottom of the vessel and discharging a jet of oil and water into the liquid.

In the apparatus shown in Figure 2, oiled mineral is blown upon the quiet surface of the liquid in a series of spitzkasten. In the ap paratus shown in Figure 3, the oiled mineral is fed down upon a rotating disc or table and is (686—608) thrown outward by centrifu gal force over the quiet surface of the liquid in a series of ring-shaped spitzkasten. Here no air is employed at all.

The result of all these processes is skin flotation or flotation of an oiled mineral by surface tension. That this is so as to the apparatus shown in Figures 2 and 3 is so apparent that no demonstration is necessary. As to the apparatus shown in Figure 1, I have tested it and have found that it is a poor device for oiling a mineral, but that it will to some extent float an oiled mineral by surface tension.

I used in my tests the apparatus put in evidence by the defendant as "Defendant's Exhibit, Apparatus of Patent 793,808." I only

added to it for my first test the inclined baffle shown near the left hand end of the apparatus in Figure 1, which performs the function of causing all of the material to be submerged so that it will
771 have a chance to become oiled. Without this the slime, mineral and gangue would float off unoiled. I tried it at first with the oil-injecting apparatus supplied as part of the exhibit by defendant. This oil feed device, however, was so constructed that, when the air pressure was applied, the air bubbled up through the oil cup and prevented the oil from feeding down into the air pipe. I cannot understand how defendant's expert, Dr. Byrnes, used this device for injecting oil with the air. The moment the air pressure is turned on, the oil feed stops, and if the air is turned on first and then the exit of the oil cup is opened, the air pressure prevents all flow of oil. I, therefore, replaced this oil feed device, which would not feed oil, by an oil feeding device which I now produce, so constructed that the air pressure flowed freely into the oil cup above (687—609) the oil. With this device and a thin and quite pure oleic acid obtained from Hegeman's Drug Store, I was able to feed the oil very effectively and thus carry out the inventors' idea of spraying the oil into the air on its way to the coil.

The following are the details of the experiment, with the coil apparatus of this patent. The ore used was defendant's ore crushed to 80 mesh, and 3,000 grams of ore were used, fed in at the rate of 500 grams per minute. The worm was rotated at a speed of 500 revolutions per minute. The air pressure applied was 5 lbs. to the square inch, running from a tank in which it was stored and controlled by a reducing valve. The total oil consumption was 30.5 grams.
772 We put in 15 cc. of 50% sulphuric acid at the commencement of the operation, and no further acid was added. The result was a few oily drops floated on the surface, one-sixteenth of an inch in diameter or less; no mineral on surface except a small surface tension float. Upon examining the pulp at the bottom of the trough, it was found to be not materially oiled. On standing, a little more oil came to the surface.

I could not verify Dr. Byrnes' statement as to this apparatus in any particular. He says that the apparatus is well adapted to oil the mineral and float it as a froth. I found that it was very poorly adapted to oil the mineral and that it did not produce any froth at all. He says that the coiled perforated pipe acts as an efficient agitator to intermingle a considerable amount of air in the pulp. I found that it simply blew air through the pulp. He says that he obtained a thick and satisfactory froth, of which he skimmed off many handfuls. I did not obtain any froth at all.

The disclosure of the Bubbles patent well indicates (688—610) the groping of Messrs. Sulman and Pacard for a practical process of ore separation by flotation. If they had stopped with the ideas disclosed in this patent, they would not have advanced the art in any respect toward the goal which they ultimately attained, with the co-operation of Mr. Ballot.

The process of the patent in suit is not disclosed in this patent

and Messrs. Sulman and Picard might well have been dis-
773 couraged by the inefficiency and practical uselessness of al-
that is disclosed in this patent from any further effort t
concentrate an ore by flotation assisted by air or gas.

6 and 7. Kirby Patents, No. 809,959, of January 16, 1906, Application Filed December 14, 1903, and No. 836,626, Patented December 18, 1906, Application Filed December 17, 1903.—The first of these two documents discloses a process of separating minerals. The second discloses a separating tank used in this process. In the process, a thin oil is used in the proportion of from 25 to 75 per cent of the ore, which is from 500 to 1500 lbs. to the short ton of ore. The oil is kerosene, having dissolved in it 5% of Trinidad asphalt.

The process is a buoyancy process, like Elmore, but the patentee hopes to assist the buoyancy of some of the particles by air. The patentee says (p. 2, lines 56-66):

"Some of the hydrocarbon-coated particles will float to the surface without assistance; but a considerable quantity of such particles will not be sufficiently buoyant, and some of such particles and some globules of the mixture would be trapped in the sands. In order to recover this less buoyant material together with the globules of the mixture, the mass which tends to settle is slowly lifted and turned over to liberate the coated particles and the globules,
and at the same time a gas, preferably air, is blown into the
774 mass, preferably near the bottom thereof."

That a floating layer of oil carrying mineral is obtained (689—611) is quite clear. The patentee says (p. 3, lines 55-57):

"The floating concentrates are carried mainly at the lower surface of the hydrocarbon layer, where it is in contact with the water."

Kirby mixes in one vessel, the mixer A, and then flows the mixture into another vessel, the separating tank B, in which this slow stirring and blowing in of air takes place and the floating layer of oil carrying mineral is formed. A skimming bar 28 carries the float into a settling and washing chamber or box 29 (Fig. 2) at the top of the separating tank, from which the float flows into a filter which recovers part of the oil. The remainder of the oil recoverable is distilled from the concentrate in a retort.

This process is so plainly an oil buoyancy process that it seems surprising that Dr. Byrnes should mislead himself into the belief that it is a frothing process.

There is absolutely no foundation for this belief. Dr. Byrnes says that the mineral "floats as a froth" in a separating tank, and that the "froth of concentrates" is directed by the curved skimming bar into the settling and washing chamber. This directly contradicts the statement of the patentee above quoted that he has here a
"hydrocarbon layer" (oil layer) in which " the floating con-
775 centrates are carried mainly at the lower surface * * *
where it (the oil layer) is in contact with the water."

As for Dr. Byrnes' alleged Kirby tests, it is as different from Kirby as is Dr. Byrnes' description.

The Kirby process is not the process of the patent in suit. It is

an attempt to use the Elmore buoyancy process with thin oil and some economy in oil. I have tested it on a small scale and found that the thin oil did not very effectively hold up the metal in the floating oil layer, (690—612) and that the streams of air only disturbed and sank the metal carried in the floating oil layer. The Kirby process is very far removed from the process of the patent in suit.

General Remarks on Processes of Ore Treatment With Oil.—There are, in the six subdivisions of this class of processes, twenty-three documents. As the Froment Italian and British patents are identical in substance, we have twenty-two inventions each aiming to solve the problem of the economical and effective concentration of ores by the utilization of the preference of oil for the mineral. These inventions commence with Haynes in 1860. Then there is a gap of more than twenty-five years. Then comes Everson in 1886, the efforts to utilize it in modified forms in 1889 and 1890, Robson in 1897, the Elmores in 1901, Froment in 1902, the Cattermole series commencing in 1903 (application for patent No. 777,273), the graphite group, Glogner, Good and Kendall, in 1903 and 1904,
the Kirby applications in 1903, the first Schwarz application
776 in 1904, the Sulman and Picard first efforts in 1904. The
Wolf process in 1904 I have considered under the heading "Apparatus." That may also be added to the list. This record of invention is a record of partial or complete failures. It is in evidence that Elmore was used to some extent and that Cattermole was used to a small extent, but both of these processes long ago disappeared from use. The amount of capital invested and lost in these unsuccessful inventions would, no doubt, make a stupendous figure. The human effort must have been very great.

But the process of the patent in suit solves the problem. It is simple, it is economical, and it is efficient. It can be used in simple apparatus. The expense (691—613) of operation is slight and the recoveries are large, yet none of these prior documents discloses it. The phenomenon of the agitation mineral froth was an unknown phenomenon until discovered by Messrs. Sulman, Picard and Ballot, and made known by them in the patent in suit, and in twenty-four corresponding patents taken out in Europe, Asia, Africa, Australia and the Americas.

125 Q. Having now considered the prior art, both as set forth by the defendant and as supplemented in complainants' rebuttal testimony, what have you to say as to the novelty of the invention disclosed in the patent in suit?

A. The process of the patent in suit is a new process, not disclosed
in any or all of the documents referred to by complainants or
777 defendant as prior documents. It was to me a most surprising process. After studying all these prior documents, my surprise is not diminished that such a process is possible. There is nothing like it disclosed in the prior art and the failures of other inventors tended to discourage rather than to encourage the hope that the economical concentration of ores was capable of

realization in a process utilizing the affinity of oil for metallic substances.

Of all the prior processes, the nearest approach to the process of the patent in suit was the Cattermole granulation process. Here there was agitation of an ore pulp with an amount of oil as small as 1½% of the ore, or 30 lbs. to the short ton, and with reasonably small quantities of acid, utilized only for its physical action in increasing the preference of the oil for the mineral. This was a simple and workable process, but it was the reverse of the flotation process. The agitation and oiling of the mineral (692—614) caused the mineral particles to stick together and form granules having greater weight in proportion to their surfaces than the original particles, so that they not only went to the bottom, but they resisted an up-current of water strong enough to carry away the gangue. This taught that the best way to concentrate an ore was to sink the metallic particles.

Then we have the Froment principle of generating carbonic acid by the use of sulphuric acid and limestone and attempting to float the mineral by the generated gas. Nothing of practical
778 value came from this principle, and there was the Sulman and Picard idea of lifting the mineral to the surface by streams of air, and nothing of practical value came from this. Then we have the oil buoyancy processes of the Schwarz and Kirby—efforts to assist buoyant action of the oil by blowing in air—and finally, we have the Elmore oil buoyancy flotation process, in which the mineral was made so light by entrapping it in great quantities of oil that the mixture of oil and mineral became lighter than water and floated. This briefly summarizes the prior art.

The simplicity of the process of the patent in suit is as remarkable as its economy. For continuous operation only two pieces of apparatus are required, an agitator for briskly agitating the ore pulp and beating air into it, and a spitzkasten or separator in which the froth may arise to the surface and float off into a launder. The oil consumption is one one-thousandths part of the weight of the ore treated, equal to 0.1%, equal to 2 lbs. to the short ton of ore. The acid consumption, since no chemical action is required or desired, is extremely small. Some heating is usually required, but this is not carried to such a point (693—615) as to be a serious item of expense.

The remarkable thing about the froth produced in this process is its permanency. The bubbles of air, with water films, are thickly coated with mineral particles and appear to be armored by these metallic particles. The froth piles up thickly and carries the great weight of the mineral particles, which are the heaviest par-
779 ticles of the ore. The oil has entirely disappeared from sight and sense. It cannot be seen and it cannot be felt, and the particles of mineral are just as bright as though there was no oil upon them at all.

I regard the process of the patent in suit as one of the most remarkable and surprising processes which has ever been brought to my attention, and the invention is one of the most important in-

ventions in the metallurgical art, and I further regard it as an entirely novel process not disclosed in the prior art.

126 Q. In considering the Froment Italian patent, you said that the thinnest possible layer of thick residuum oil required a quantity of oil 11.7% of the ore. What particular oil did you use in this test, and what capacity of test tube?

A. It was what is known as Winter Dark oil; sample just received from London. I believe it is about the thinnest residuum oil that is known in the art of ore treatment. The Summer Dark oil is darker and a thicker oil than the Winter Dark oil, and I tested this and found that it required 1.4 grams of oil to make a layer on water in an 80 cc. test tube, equal to 14.4% of oil on the ore.

I was present on November 5, 1912, when Dr. Liebmann repeated his test tube reproductions of Dr. Byrnes' alleged Froment slide machine tests. I made careful notes of (694—616) all these tests and can repeat them if desired. The tests which I have particularly described in my testimony were made later.

780 The term "powdered" as used in the patent in suit is not limited to dry pulverization. When a substance is not soluble in water, it is quite common to grind it under water to an impalpable powder or pulp, which may or may not afterwards be dried. This is a very common custom with minerals, and has long been employed both for ores and for quartz, feldspar, etc., as used in the porcelain industry.

Sulphuretted hydrogen is a gas having a very characteristic and disagreeable odor. It is very offensive and poisonous, and I have heard of workmen being killed by it in factories where it was liberated; in fact, one of my assistants working in my laboratory was rendered insensible by it. Fortunately I was present, and with the assistance of two of my students I carried him at once into the open air and he recovered. As sulphuretted hydrogen is a very valuable reagent in chemical analysis, it is often employed in laboratories and its odor can often be perceived, but it is customary to have specially constructed hoods, well ventilated, in which the apparatus is placed while the gas is being utilized.

I have tested the apparatus "Defendant's Exhibit Apparatus of Patent in Suit," without using baffles in the cone mixer. The boxes or spitzkasten were filled with circuit water at a temperature of 50° centigrade. The ore employed was defendant's crushed to pass through an 80 mesh sieve. 500 grams of ore and 3,200 cc. of water, and 3 cc. of oil of vitriol were put into the agitator. This quantity of acid was employed on account of the large (695—

781 617) amount of water in the agitator and the spitzkasten. The oil employed was defendant's red oil. The quantity employed was 0.75 cc., which is equivalent to 0.675 grams, which would be 2.70 lbs. per ton of ore, equal to 0.13% on the ore. The ore, etc., was agitated for about two minutes by hand, with frequent reversals of direction. There were no baffles in the agitator. There appeared half an inch of froth in the agitator, and when the contents of the agitator were discharged, the froth ran out on the launder and floated on the spitzkasten. Considerable froth was left in the agi-

tator. I should add that, before this experiment was made, a gate valve was substituted for the globe valve which was on the original exhibit. This facilitated the discharge of the froth. The apparatus of the patent was intended for continuous use, and such a test as this is not a fair test of the apparatus, and, as it was worked by hand, it did not give sufficient agitation. But, nevertheless, there was a considerable amount of froth in evidence.

Cross-examination:

Wood tar is a product of the destructive distillation of wood. If the wood is a resinous wood the first product of distillation will be water, then will come oil of turpentine, then a series of chemical products, known in commerce as pine oils and pine tar.

The pine oil and sweet pine oil resulting from destructive distillation of wood would be in the tar if the distiller did not collect them separately. They belong primarily to the tar, but in
782 recent years the distiller has collected separately the first portion of the distillate, which is pine oil. I think it is proper to (696—618) call pine oil a derivative of wood tar just as we call phenol and cresol derivatives of coal tar.

140 X Q. Referring to Dr. Byrnes' experiment with the Kirby process as described by him, will you state how much blende could theoretically be floated in water by the 125 grams of kerosene used by Dr. Byrnes, without the assistance of any buoyancy derived from air, but relying exclusively upon the buoyancy imparted by the kerosene by virtue of its specific gravity?

A. I have reduced this problem to a formula, as follows: Let X equal the volume of oil to be added to one volume of blende to reduce the specific gravity of the mixture to unity, that is, to the specific gravity of water.

The formula is as follows:

$$X = \frac{\text{Specific gravity of Blende—1}}{\text{1—Specific gravity of oil.}}$$

This formula as applied to blende and kerosene oil is as follows:

$$X = \frac{4-1}{1-0.7935} = \frac{3}{0.2065}$$

The result of this equation is:

$$X = 14.65 \text{ volumes of oil.}$$

Dr. Byrnes used 125 grams of kerosene. This would be sufficient to float 43.2 grams of sulphide of zinc or blende. The 500
783 grams of ore contain 30% of blende, which would be 150 grams of this mineral. If the 125 grams of oil floated 43.2

grams of blende, then there were 106.8 grams of blende not floated by oil, theoretically, of course. If Dr. Byrnes had used Kirby's maximum of oil, 735 grams or 75% of the ore, he could theoretically have floated 129.6 grams of blend, still leaving 20.4 grams not provided for. (697—619)

The specific gravities of the different oils listed below are as set opposite the names of those oils.

Crude petroleum	0.8156	to	0.7978
Kerosene	0.807	"	0.7935
Lubricating Oil	0.885		
Residuum Oil	0.900		
Pine Oil	0.9571	"	0.8696
Sweet pine oil or pinoline	0.940		
Oil of wood tar	1.030		
Cotton-seed Oil	0.920	"	0.926
Eucalyptus Oil	0.850	"	0.925
Olive Oil	0.914	"	0.919
Turpentine	0.865	"	0.875
Oleic acid	0.900		

The above figures are not exact, because there are slight variations in the processes of different manufacturers.

In the case of an oil having a specific gravity of .8 and of zinc blende or sulphide having a specific gravity of 4, it would be necessary to use three parts by weight of oil to one part by weight
784 of zinc blende to form a mixture having a specific gravity of 1, that is, having the same weight as water. In the case of an oil having a specific gravity of 9 it would be necessary to use 6.7 parts by weight of oil to one part of zinc sulphide, and in the case of an oil having a specific gravity of .95 it would be necessary to use 15.7 parts of oil to one of zinc blende by weight to form mixtures having specific gravities of one, that is, of the same weight as water.

The offer made during the deposition of (698—620) Dr. Liebmann to repeat any of the tests or experiments testified to by the witness is here repeated as to the experiments referred to by Dr. Chandler in his deposition.

Redirect examination:

146 R. D. Q. Does or does not the statement in the claim of the Froment Italian patent, that the oil must have an "oily fat body," exclude pine oil and sweet pine oil from the oil or oils thus described?

A. It does exclude them. (699—621)

Testimony for Complainants of A. Howard Higgins, Recalled.

The original cone mixer used by me for the production of a agitation mineral froth in March, 1905, has been worn out an scrapped. I produce a substantial reproduction of that apparatu containing baffles such as were in that apparatus.

The apparatus produced by the witness is offered in evidence an marked "Complainants' Exhibit, Cone Mixer."

785 The apparatus which was produced by Dr. Chandler as th modified oil feeding apparatus used by him in the test mad by him of "Defendant's Exhibit, Apparatus of Patent No. 793,808," is also offered in evidence and marked "Complainants' Exhibit, Modified Oiling Apparatus."

It is not possible for us to produce the series of cone mixers an the series of spitzkasten such as are shown in the drawings of th patent in suit which were the original apparatus used in the labor tory of Minerals Separation, Limited, in the year 1905. This app ratus has also gone into the scrap heap.

Dr. Liebmann's experiments described in his testimony with "D fendant's Exhibit, Apparatus of Patent 793,808" were made in m presence and Dr. Liebmann used "Complainants' Exhibit, Mod fied Oiling Apparatus" as the apparatus for obtaining the oil fe which he describes.

Dr. Liebmann's second experiment, carrying out the Everson i vention, was made in my presence. The concentrate (700—622 was removed by a constant overflow of acidulated water.

I have had an assay made of the original ore, concentrates an tailings of Dr. Chandler's experiment carrying out the instructio of the Everson patent as to the second mode of treatment describe therein. The result of the assay is as follows:

Original ore,	Zinc	21.8%	Insolubles	58.2%
Concentrates,	"	15.8%	"	67.6%
Tailings,	"	22.0%	"	57.6%

I have had a drawing made on a smaller scale followin

786 the large blue-print "Complainants' Exhibit, Drawing Aus tralian Model Plant." This smaller scale drawing, which now produce, represents this plant as used in Minerals Separatio laboratory. In each of the partitions between the agitation box four holes were provided, one or more of which were closed by plug for the purpose of experiment in using different combinations o openings.

"It is stipulated that the drawing now produced may be sub stituted in place of the large blue-print marked 'Complainnts' E hibit, Drawing Australian Model Plant,' as an exhibit herein, th blue-print, however, to be produced upon demand."

It is also stipulated that the drawing marked "Complainants' E

hibit Froment Plan," be replaced in evidence by a reduced drawing thereof now produced (701—622½) and similarly marked, the original, however, to be produced at any time upon demand.

The same stipulation is made as to "Complainants' Exhibit, Froment Drawing A" and as to "Complainants' Exhibit, First Tracing of Slide Machine."

I have made tests in a modern continuously operating plant for the production of the agitation froth, using cotton-seed oil in the proportions used by Dr. Byrnes in his second test in the slide machine, alleged to be an operation of the Froment British patent. I made these tests at Butte, Montana, in a plant substantially the same as that shown in the drawings "Complainants' Ex-
787 hibit, King John's Court Standard Plant," with the exception that there were six spitzkasten instead of five. The apparatus is a small one, having a capacity of 10 lbs. of ore per minute. The ore used was from the Elm Orlu mine, which is adjacent to the Black Rock mine of the Butte & Superior Copper Company. With the exception of the presence of some clay in the ore, it was practically identical with the Black Rock ore. After being crushed to 80 mesh, it was fed to the plant at the rate of 10 lbs. per minute, sulphuric acid and cotton-seed oil being fed in the proportions used by Dr. Byrnes in his second test. In about three minutes the plant had settled into a permanent condition. The float on the first spitzkasten was copious, being about one inch to an inch and a half deep, and though oily in appearance when closely examined, did not differ in appearance from the usual agitation froth at a distance of a few feet. These floats were exceedingly dense and occasionally (702—623) fell down in large masses. The tailings contained some granules, and did not indicate a satisfactory recovery. Samples were taken of these products and assayed:

Original ore,	Zinc	20.41%	Insolubles	59.95%
Concentrates,	"	47.54%	"	11.82%
Tailings,	"	12.94%	"	72.24%

giving a recovery of 50% of the zinc in the concentrates.

The small plant that I used is nominally a five-ton plant, although its maximum capacity is seven tons per day. This plant is
788 not intended for commercial use in treating zinc ores, being only a testing plant. The percentage of oil used in the test was 3.6 on the ore, corresponding to the 20 cc. of cotton-seed oil used by Dr. Byrnes.

No cross-examination. (703—624)

Testimony for Complainants of George A. Chapman, Recalled.

"Complainants' Exhibit Reproduction of Froment Mixer" and "Complainants' Exhibit Reproduction of Froment Vat with Coil" are an almost exact reproduction of the old Froment apparatus which I used about 1904. The Froment mixer appears to be a little bit

larger in diameter, but the rotating devices inside are almost exactly the same as in the old apparatus. The only difference that I can see is that screws hold the teeth in place instead of rivets. My memory is refreshed by seeing this device and I want to correct a statement that I have made before that the agitator consisted of wire beaters. My memory was confused at that time because of the Robson & Crowder mixer which we had in the laboratory at a later time than when I used the Froment mixer and in which there stout wires something like a grid. We also had in the laboratory a mixer like an egg beater. That was used in connection with the tests on breaking down Cattermole granules. The memory of these different apparatus confused me, but now that I have seen this Froment reproduction, I am very sure that the old Froment mixing device has been here substantially reproduced.

789 I may add, however, that there was a sort of hopper on the side of the old Froment Mixer, which I understand from Mr. Higgins it was not deemed necessary to reproduce.

The vat with coil agrees exactly with the description that I gave before. As I think it over carefully, it may be possible that the points of the rake were sharpened (704—625) in the old Froment apparatus, but I am sure this would not make any difference.

I have heretofore described bottle tests of the operations set forth in the patent in suit, with 20 grams of ore and 70 grams of water. With such an amount of ore, one drop of oil would be more than 1½ to 2 lbs. to the ton. The only way to get a small enough quantity of oil for such a test would be to use a soap solution, which could be made sufficiently weak to carry the fraction of a drop of oil that would be required in such a test. This would be decomposed by the sulphuric acid and the oil set free. I am quite sure that I have made tests that way, although tests of this kind are only rough tests to indicate the possibility of obtaining the agitation froth with an ore. Never at any time have I used this method for a quantitive test. The slide machine is the usual apparatus for the first quantitive test.

I have made tests in a modern continuously operating plant for the production of the agitation froth, using cottonseed oil in the proportions used by Dr. Byrnes in his second test in the

790 slide machine, alleged to be an operation of the Froment British patent. I made a test in the London Standard plant. This is the same plant described by Dr. Liebman, containing eight agitators and six flotation boxes and it was used in the same conditions as when Dr. Liebmann used it in his London experiments. This is known as a fifty ton plant and could be worked at that capacity at a mine, but it is used for testing purposes only and never run to its full capacity. (705—626)

The ore that I used was Broken Hill tailings, containing about 18% of zinc and about 5% of lead. This ore was crushed to pass through an 80 mesh screen. The plant was operated for an hour and 1680 lbs. of ore were fed in during this period. Cottonseed oil was used in the proportion of 3.6% of oil on the weight of the ore and the acid consumption was 0.37% on the weight of the ore

(1 cc. is 1.8 grams, which is 0.368% of 492 grams of ore). The temperature of the water was maintained at 70° Fahrenheit.

An oily float was obtained, some of which was carried below the surface of the water. I made adjustments so as to carry this float over; certainly more than 30% of it was carried below the surface of the water. There were large, clean, oil-film bubbles in it and it did not look at all to me like an agitation froth such as is obtained under normal and economical conditions of oil consumption. The float looked oily and it was oily to the touch, whereas the normal agitation froth does not show the presence of oil nor can you feel that
791 there is any oil in it.

The tailings were oily and dirty and contained incipient granules. I took some of these tailings and rolled them in a Gabbett without baffles and obtained good granules.

I separated the concentrates which overflowed from the six flotation boxes and had them separately assayed, and also had the tailings assayed.

The returns were as follows: (706—627)

Experiment No. 1.

	Weight Total Lbs.	Percentages Insol.	Zinc.	Lead	% Recov. Zinc.	Lead.
1st. Conc.	26.6	14.1	28.8	9.0	2.52	2.92
2nd Conc.	21.7	12.6	29.9	8.9	2.14	2.35
3rd Conc.	14.2	11.0	31.4	8.8	1.47	1.52
4th Conc.	25.2	11.2	30.7	8.9	2.54	2.72
5th Conc.	21.2	20.5	26.7	7.3	1.87	1.87
6th Conc.	20.6	14.2	30.9	8.5	2.1	2.12
Tailings	1550.5	——	17.1	4.6	87.5	86.6

The recoveries of zinc and lead in the total concentrates were, zinc, 12.6%; lead, 13.6%.

The amount of sulphuric acid used by Dr. Byrnes was less than the normal amount used in the agitation froth process for Broken Hill tailings, and so I ran another test, using an acid, consumption of 25 lbs. to the ton, which is rather more than the normal acid requirement of this ore when using the agitation froth process under proper conditions. Everything else, as to temperature, time, materials, etc., was exactly the same as in the test just described.

The results were assayed and the assay returns were as
792 follows: (707—628)

Experiment No. 2.

	Weight Total Lbs.	Percentages Insol.	Zinc.	Lead	% Recov. Zinc.	Lead
1st. Conc.	71	6.0	37.9	9.0	9.03	8.73
2nd Conc.	51	5.8	38.2	9.0	6.58	6.27
3rd Conc.	39	7.3	36.3	8.7	4.8	4.63
4th Conc.	34	8.4	35.6	8.5	4.1	3.95
5th Conc.	27	11.2	34.6	8.1	3.12	3.00
6th Conc.	27	5.2	38.6	8.5	3.5	3.13
Tailings	1431	——	14.2	3.6	68.6	70.25

The recoveries of zinc and lead in the total concentrates were, zinc, 31.13%, and lead, 29.71%.

The results of this second test were a little better than of the first test. They were both wasteful in the great quantities of oil used and absolute failures as to the results.

I took some of the tailings from my test No. 2 above described and made granules from them by rolling them in a cone mixer or Gabbett without baffles. I have brought a specimen of these granules with me and I now produce it.

The floating material obtained in this second test was practically the same as in the first, only it contained more mineral and less gangue.

After I had made these two tests, it was suggested to me by our patent agent, Mr. Ballantyne, that I would more nearly parallel Dr. Byrnes' tests by having less agitation. Dr. Byrnes agitated in a slide machine for thirty seconds for his agitation and from ten or twenty seconds each for his subsequent agitations. We usually agitate one and a half to two minutes for the first agitation in the slide machine, and half a minute to one minute for subse-
793. quent agitations. To repeat this condition of under agitation, I made another test with proportions (708—629) of all material, temperature and time the same as in my experiment No. 1, but using only six agitators, one agitator for each of the six flotation boxes. The results were a slight improvement on the results in test No. 1. The floating material was the same and the tailings contained incipient granules which I granulated as I have described before. The results were assayed and the assay returns were as follows:

Experiment No. 3.

	Weight Total Lbs.	Percentages Insol.	Zinc.	Lead.	% Recov. Zinc.	Lead.
1st Conc.	25.3	12.5	30.5	7.8	2.36	2.06
2nd Conc.	37.6	10.4	33.3	7.6	3.84	3.00
3rd Conc.	31.0	10.6	34.1	8.0	3.24	2.60
4th Conc.	46.3	10.8	34.1	7.9	4.84	3.82
5th Conc.	42.0	14.5	33.0	8.1	4.25	3.56
6th Conc.	23.0	11.7	33.6	7.5	2.36	1.81
Tailings 1474.8		——	17.5	5.4	79.1	83.2

The recoveries of zinc and lead in the total concentrates were, zinc, 20.89%; lead, 16.85%.

The speciment of granules produced by the witness is offered in evidence and marked "Complainants' Exhibit, Cattermole Granules, Chapman London Test."

I have also made a test in the same plant, using oleic acid in the proportion of 1.8 per cent on the ore and the proportion of sulphuric acid given by Dr. Byrnes and used by me in my experiments 1 and 3 with cottonseed oil. I made this test using a very good oleic acid, purer than the ordinary red oil of Commerce. The
794 floats were (709—630) very bulky and contained a very high proportion of gangue and very little enrichment of the crude ore took place. The procedure was altogether wasteful, and the result of no commercial value at all. If the agitation froth process when properly used gave any other results as this, it would never have been adopted for practical use. The float obtained was oily in appearance and oily to the touch, but not as oily as in the other tests where I had used cottonseed oil and had used twice as much oil.

I used the same Standard plant with six agitators and six flotation boxes in operation, so as to come as near as possible to Dr. Byrnes' conditions. The time and temperature, and quantity of ore were the same as before, and the sulphuric acid was the same as in my cottonseed oil tests Nos. 1 and 3. The concentrates were separately assayed and the tailings were assayed. The assay returns were as follows:

Experiment 4.

	Weight Total Lbs.	Percentages Insol.	Zinc.	Lead.	% Recov. Zinc.	Lead.
1st Conc. 138		25.3	24.5	6.9	10.95	10.80
2nd Conc. 284		30.0	22.3	6.2	20.55	20.15
3rd Conc. 151		30.3	21.9	6.4	10.70	11.05
4th Conc. 152		29.5	22.6	6.6	11.17	11.52
5th Conc. 146		33.8	20.5	6.0	9.75	10.01
6th Conc. 99		34.4	20.7	5.7	6.66	6.47
Tailings 710		——	13.1	3.7	30.22	30.00

The recoveries of the zinc and lead in the total concentrates were, zinc, 69.78%; lead, 70.40%. (710—631)

795 I would say that these recoveries were in a concentrate of so low a grade that it would really not be considered a concentrate. If you were to take a ton of ore and shift it from one bin to another, you would have 100% of your mineral in the second bin.

In one instance, as to my experiment No. 1, with cottonseed oil, I made careful gas analyses with an exact repetition of this run. It took quite some time to collect the gas in the float, but I got a fair specimen from each of the first four flotation boxes. The actual volume of air or gas in the floats was very much less than in the normal agitation froth, but my tests showed that the proportion of CO_2 in this gas was less than we have found it in many gas analyses of the normal agitation froth and kept on getting less in the successive boxes. I made two series of tests to correct any possible error in one of them, and I give below the results obtained from each analysis, and the average of the two analyses:

	1st Analysis.	2d Analysis.	Average.
1st Box CO_2	2.8%	3.1%	3 %
2d Box CO_2	1.4%	1.8%	1.6%
3d Box CO_2	1.1%	0.9%	1 %
4th Box CO_2	0.6%	0.8%	0.7%

I used all the sampling glasses that I had for these analyses and had no further glasses for the fifth and sixth boxes.

I made two tests in the ordinary slide machine with 500 grams and 400 grams of Broken Hill tailings and other quantities in the proportions given in the Froment British patent. (711—632)

796 First I determined how much oil would make a layer in an 80 cc. test tube of the oil which I used, which was Winter dark oil, the oil which was ordinarily used in the Elmore bulk oil flotation process at the time of the year, the present month of December, when I made the test. I found that 41 drops of Winter dark oil or 1.4 cc. or 12.6% of 10 grams of ore was the smallest amount to produce a layer. I noted the temperature of the room at the time, which was 65° Fahrenheit.

1st Experiment, Froment. I used 500 grams of Broken Hill tailings crushed to pass through a 60 mesh screen, and 50 grams of calcite similarly crushed; 1500 cc. of water, 150 cc. dilute sulphuric acid (containing 50 grams of mono-acid or concentrated sulphuric acid); and 70 cc. of Winter dark oil. I mixed the ore, calcite and water first to wet the ore and calcite. The acid and oil were then added and I put on the full current of the motor for two seconds. There was a violent evolution of gas, which caused a portion of the contents of the slide machine to be thrown out, and because of this loss, I abandoned the test. As a matter of fact, the float rose more than 7½ inches, which was the distance from the water level to the top of the machine and overflowed.

2d Experiment, Froment. Here I used only 400 grams of ore and reduced all other quantities in the same proportion. The quantities used were as follows:

797 400 grams Broken Hill tailings
40 " calcite
1200 cc. water
120 cc. dilute sulphuric acid (40 grams acid)
56 cc. Winter dark oil. (712—633)

I mixed the ore, water and limestone as before, then added the acid and oil and agitated for two seconds as before. The float rose to within two inches from the top of the slide machine, but subsided to a float of about four or five inches in thickness after the violent evolution of the gas had ceased. After this violent evolution had ceased and the float had subsided, I took a sample of gas from the float and made two analyses of it as before. The first analysis showed that the gas in the float was 97.3% carbon dioxide; the second analysis gave 97% of carbon dioxide. The average of the two analyses was 97.15% carbon dioxide. My analysis of these gases determined the amount of carbon dioxide present. The rest of the gas, less than 3 per cent, was probably air. There was no odor of sulphuretted hydrogen in the gases. This was true as to all of the tests I have described in this deposition. During the cotton-seed oil tests there was an unpleasant odor which had the effect of making me sick, and those working with me showed evidence of sickness and complained of sickness.

254 Q. Did you observe any effects on the apparatus of the use of cotton-seed oil and oleic acid in the proportions used in these tests?

A. Parts of the plant were left in a dirty and greasy con-
798 dition, which made it necessary to scrub all accessible parts with alkaline soft soap solution after the completion of the tests. After each series of tests we circulated a nearly boiling solution of weak alkaline soft soap through the entire plant, using in each lot 50,000 gallons (713—634) of water and circulating it around for about twelve hours. All of these efforts did not clean the plant so that it could be used for normal agitation froth working. We then put several charges of ore pulp through the plant and finally restored it to condition for testing under normal conditions. It was nearly a fortnight before the plant was again in working order.

255 Q. Does normal agitation froth operation make a plant greasy as did the tests you have described?

A. No. The oil disappears. The dirt in the plant is never greasy.

Relative to the testimony of the defendant, James M. Hyde, as to the applicability of oil concentration processes Mr. Hyde appears not to be well informed as to the wide usefulness and application of the agitation froth process. It is applicable to the three copper sulphides appearing in ores, these three forms being chalcopyrite, chalcocite and copper glance. Mixed sulphide ores treated by it are usually marketable as concentrates, for example all

Broken Hill concentrates are sold as a mixed concentrate of zinc and lead. The Swedish ore of the Saxbergets mine, when
799 treated by the agitation froth process, produces a mixed concentrate consisting of zinc blende, galena (lead sulphide), and pyrrhotite (magnetic sulphide of iron). The pyrrhotite is separated by magnetic treatment and the zinc blende and galena are separated on water concentration tables, as described by me in my testimony.

As a matter of fact, the smelters penalize Broken Hill concentrates if they do not contain with the blende (714—635) a fair proportion of lead.

257 Q. Do you know of any instance where cotton-seed oil is used in the agitation froth process?

A. No. It costs more than oleic acid and is not as well suited as oleic acid. We have never considered it as a likely oil for this process.

No cross-examination.

The slide machine used in Dr. Chandler's experiments for his testimony in the prima facie case, as well as in subsequent experiments in New York City, is offered in evidence as "Complainants' Exhibit, Slide Machine."

The following documents heretofore marked for identification, are offered in evidence and entitled respectively "Complainants' Exhibit" and the title hereinafter given by which they were identified when marked for identification:

"Cable, Hoover to Hyde, January 18, 1910";
"Cable, Hyde to Hoover, January 20, 1910";
"Cable, Hoover to Hyde, January 21, 1910";
"Cable, Hyde to Hoover, January 24, 1910";
"Letter, Mineral Separation to Hyde, March 2, 1910";
800 "Hyde Acceptance, March 3, 1910";
"Cable, Minerals Separation to Hyde, Dec. 8, 1910";
"Cable, Hyde to Minerals Separation December 9, 1910";
"Letter, Minerals Separation to Hyde, November 23, 1910";
"Hyde Report, January 8, 1911"; (715—636)
"Copy Memorandum re Managership of Minerals Separation American Syndicate, Limited";
"Letter, Hyde to Minerals Separation American Syndicate, January 17, 1911";
"Letter, Minerals Separation to Hyde, February 1, 1911."

It is noted, that as to those of the above documents which were produced by the defendant, by stipulation, the original documents produced by him have been returned to him and replaced by copies to have the same force and effect as the originals, the originals to be produced upon demand.

Complainants here close their testimony.

801 *Stipulations Other Than Those Noted in Connection with the Testimony of the Witnesses.*

It is stipulated that Minerals Separation, Limited, and Minerals Separation American Syndicate, Limited, the complainants, are corporations duly organized and existing under the laws of Great Britain and are inhabitants of Great Britain, having their principal offices in London, England.

Counsel for complainants produces the patent in suit, No. 835,120, granted November 6, 1906, and also a certified copy thereof, and it is stipulated that the said certified copy may be offered in evidence with the same force and effect as the original letters patent. The said certified copy is offered in evidence as "Complainants' (716—637) Exhibit Patent in Suit."

Counsel for complainants produces an acknowledged assignment from the patentees, Henry Livingston Sulman, Hugh Fitzalis Kirkpatrick-Picard, and John Ballot, to Minerals Separation, Limited, dated December 7, 1909, and also a copy thereof, and it is stipulated that the copy may be offered in evidence with the same force and effect as the original assignment, subject, however, to the production of the original upon request. The said copy is offered in evidence and marked "Complainants' Exhibit, Assignment."

Counsel for complainants produces an agreement bearing date October 10, 1910, between Minerals Separation Limited, and Minerals Separation American Syndicate, Limited, the same
802 having been acknowledged, and also a copy thereof, and it is stipulated that the copy may be offered in evidence with the same force and effect as the original agreement, subject, however, to the production of the original upon request. The said copy is offered in evidence and marked "Complainants' Exhibit, License Agreement."

Counsel for complainants offers in evidence a certified abstract of title of the patent in suit, and it is marked "Complainants' Exhibit, Abstract of Title."

It is stipulated that printed Patent Office copies of the specifications and drawings of Letters Patent of the United States and Great Britain may be introduced and shall be received in evidence with the same force and effect as original Letters Patent or duly certified copies thereof, as to all the facts set forth in said printed copies including the dates of filing of the application for said (717—638) Letters Patent and the issuance thereof, subject to correction by other proof.

It is stipulated that statements in the printed Official Journal of the British Patent Office as to the sealing dates of British patents shall be accepted as prima facie proof thereof, subject to correction by other proof.

It is stipulated that original depositions and exhibits introduced in connection with this suit may be delivered to and remain in the custody of counsel for the party taking said deposition, to be filed in court at or before the hearing, subject to the examination and

proper use of any depositions or exhibits by opposing coun-
803 sel on reasonable notice.

It is stipulated that, pursuant to Clause 17 of the agreement between Minerals Separation, Limited, and Minerals Separation American Syndicate Limited, complainants herein (such license agreement being in evidence as "Complainants' Exhibit License Agreement"), the license and option to Minerals Separation American Syndicate, Limited, under the patents referred to in the schedule annexed to said agreement, including the patent in suit, have been extended for a further period of one year from October 10, 1912, and that this stipulation shall have full force and effect as evidence of that fact.

It is further stipulated, as to all printed or written documents produced in evidence, that the copies thereof in the printed records shall take the place of the original documents, the originals to be produced upon demand. (718—639)

It is noted that as to all assays in evidence, it was stipulated that the assays would be accepted as evidence without the production of the assayer as a witness.

It is hereby certified that in so far as testimony herein appears by question and answer. It is by direction of the Judge of this court:—Ordered this Nov. 6, 1913.

GEO. M. BOURQUIN, *Judge.*

The foregoing statement of the evidence and proceedings in the cause named in the caption is in due time presented to the Judge of this court and is approved by the Judge aforesaid as true,
804 complete and properly prepared.—Ordered this Nov. 6, 1913.

GEO. M. BOURQUIN, *Judge.*

Condensed Statement of Evidence. Filed Nov. 6, 1913. Geo. W. Sproule, Clerk. (719—640)

Complainants' Exhibits.

Filed Nov. 6, 1913. Geo. W. Sproule, Clerk.

COMPLAINANTS' EXHIBIT, ASSIGNMENT.

United States, No. 835,120.

Whereas, we, Henry Livingstone Sulman and Hugh Fitzalis Kirkpatrick-Picard, both of 44, London Wall, in the City of London, England, Metallurgists, and John Ballot of 62 London Wall, in the City of London, England, Merchant, did obtain Letters Patent in the United States for "improvements in ore concentration," which Letters Patent are numbered 835120 and bear date the 6th day of November, One thousand nine hundred and six.

And whereas we are now the sole owners of the said Letters Patent and all rights under the same,

And whereas Minerals Separation, Limited, of 62, London Wall, in the City of London, England, is desirous of acquiring the entire interest in the same.

Now therefore to all whom it may concern, be it known that for and in consideration of the sum of One Dollar to us in hand paid, the receipt of which is hereby acknowledged, we the said Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and
805 John Ballot have sold, assigned, transferred and by these presents do sell, assign and transfer unto the said Minerals Separation, Limited, the whole right, title and interest in and to the said "improvements in ore concentration," and in and to the Letters Patent therefor aforesaid; the same to be held and enjoyed by the said Minerals Separation, Limited, for its own use and behoof and for the use and behoof of its legal representatives, to the full end of the term for which said Letters Patent are or may be granted, as fully and entirely as the same would have been held and enjoyed by us had this Assignment and Sale not been made. (720)

In testimony whereof we have hereunto set our hands and affixed our seals at London, England, this seventh day of December, 1909.

HENRY LIVINGSTONE SULMAN. [L. S.]
HUGO F. K. PICARD. [L. S.]
JOHN BALLOT. [L. S.]

2 witnesses:
HARRY SHIRLY.
H. C. HANKINS.

Acknowledgement.

Recorded in United States Patent Office August 28, 1911.

COMPLAINANTS' EXHIBIT LICENSE AGREEMENT.

This agreement made the tenth day of October, one thousand nine hundred and ten, between Minerals Separation,
806 Limited, having its registered Office at 62 London Wall, in the City of London (hereinafter called "the Company") of the one part and Minerals Separation American Syndicate, Limited, having its registered Office at 62 London Wall aforesaid (hereinafter called "the Syndicate") of the other part, whereas the Company are the owners of various processes for the separation of minerals from gangue covered by patents taken out in the United States of America and in the Dominion of Canada, short particulars of which are contained in the Schedule hereto, and whereas the Syndicate has been formed for exploiting and for conducting experiments for the treatment of ores by the Company's said processes in the United States of America and (721—2) Dominion of Canada and also for acquiring and turning to profitable account ores, tail-

ings, dumps and also mining and other properties believed to contain minerals amenable to treatment by the Company's processes with a view to utilizing such processes in the said United States of America and Dominion of Canada in connection therewith and of securing options of purchase of ores, tailings, dumps and mining and other suitable properties or substantial interests therein and otherwise giving effect to the objects of the Syndicate as defined by its Memorandum of Association, and whereas the Syndicate has been registered in England under the Companies (Consolidation) Act of 1908 with a nominal capital of Fifty-two thousand five hundred pounds, divided into Fifty thousand "A" shares of
807 One pound each and Fifty thousand "B" shares of One shilling each, and whereas by the Syndicate's Articles of Association it is provided that the Syndicate shall enter into and carry into effect an *argument* therein referred to being these presents, now it is hereby mutually agreed between the parties as follows:

1. For the consideration hereinafter appearing the Company doth hereby give and grant unto the Syndicate (1) the sole and exclusive right, license, power and authority to apply, use and exercise in the United States of America and in the Dominion of Canada but not elsewhere all or any of the inventions, processes, apparatus, plant or machinery described in the Specifications of the Letters patent of the United States of America and of the Dominion of Canada shortly described in the Schedule hereto for the term of two years from the date hereof, subject nevertheless to (722—3)

* * * * * * *

(2) The option or right to purchase the said American and Canadian Letters patent under and in accordance with Clause 13 hereof.

2. The Company will at any time during the said term grant to any person, firm or Company nominated by the Syndicate for the purpose and approved by the Company (such approval not to be unreasonably withheld) full license and liberty to use the said processes in the United States of America and in the Dominion of Canada but not elsewhere in the treatment of ores obtained from properties to be specified in the said License upon such terms
808 as may from time to time be mutually agreed between the Company and the Syndicate, but the Syndicate shall not be entitled to assign the license hereby granted or any of its benefits hereunder or to grant sub-licenses without the consent of the Company first obtained.

* * * * * * *

3. Part of the consideration for the exclusive license and the other rights and interests hereby granted to the Syndicate by the Company shall be the sum of Seven hundred and fifty pounds, which shall be satisfied by the allotment forthwith to the Company or its nominees of Fifteen thousand fully paid "B" shares in the capital of the Syndicate of One shilling each.

4. As further part of the said consideration for the said License the Company shall be entitled to a further One thousand seven hundred and fifty pounds to be paid and satisfied from time to time

by the allotment to the Company or its nominees of one fully paid "B" share for every "A" share that may be subscribed for from time to time in (723—4) addition to the Fifteen thousand "A" shares which are to be subscribed for forthwith, the intention being that when the Fifty thousand "A" shares are subscribed for the Company shall be entitled to the Fifty thousand "B" shares of One shilling each fully paid.

5. As the residue of the consideration for the said License the Syndicate agree that during the said term of two years the Syndicate will use their best endeavor to apply and turn to profitable account in the United States of America and in the Dominion of Canada the processes and inventions covered by the said patents and in particular to secure and deal with in terms of the Memorandum of Association of the Syndicate options (calculated to yield profit) upon mines, ores, dumps, tailings, slimes and other suitable mining products and to secure users of the said processes on license for royalties or on profit sharing basis or otherwise. * * *

13. For the considerations before mentioned the Syndicate shall be entitled at any time during the said term of two years unless the license hereby granted shall have been previously determined to purchase all the said Patents of the United States of America and Dominion of Canada and the Company if the Syndicate's option shall be duly exercised will sell such patents accordingly upon the conditions following:

(*a*) The consideration for such sale shall be a sum payable in fully paid One pound shares of a New Company to be registered by the Syndicate in England to acquire the said Patents equal to one half of the total registered nominal capital of such new Company (724—5) which shall be accepted in substitution for all the Company's rights in respect of "B" shares in the Syndicate of one shilling each then held by them or their nominees except the right to participate in surplus assets on any distribution in a winding up of the Syndicate.

(*b*) The total nominal capital of the said new Company shall be not less than two hundred thousand pounds and such capital shall be divided into shares of One pound each and at least one-fourth of the total nominal capital of such new Company shall on or before completion of the sale be allotted to responsible persons on subscriptions for payment in full of cash free of all deduction in respect of underwriting commission or other charges or expense of any kind.

* * * * * * *

(*d*) The said sale shall be made subject to any license which may be granted under clause 2 hereof, but the new Company shall after the said sale be entitled to the royalties or other consideration payable under any such license.

(*h*) Unless the said purchase shall be completed upon the conditions hereinbefore mentioned and on or before the expiration of the said term of two years the said option shall cease and all the agreements and obligations on the part of the Company under this Agree-

ment shall be at an end and for the purposes of this clause time shall be deemed to be of the essence of the Contract. (725—6)

* * * * * * *

17. In the event of the Syndicate being desirous of having an extension of the option hereby granted and of such desire shall give to the Company notice in writing not less than three months prior to the expiration by effluxion of time of the license granted by clause 1 hereof then the Company will on the Syndicate paying to the Company the further sum of Five thousand pounds in cash extend the license and option hereby given for a further period of
811 one year and in such case this Agreement shall be read and construed as if the license granted under clause 1 hereof had originally been granted for three years instead of two.

As witness the respective Common Seals of the Companies parties hereto. (726—7)

The Schedule Hereinbefore Referred to.

United States of America.

No.	Date of patent.	Name of applicant.	Description.	Known as
777,273	13.12.04	A. E. Cattermole	Separation of the metallic constitutents of ores from gangue	Separator
763,259	21. 6.04	A. E. Cattermole	Classification of the metallic constituents of ores	Classifier
763,260	21. 6.04	A. E. Cattermole	Separation of the metallic constituents of ores from gangue	Separator
798,808	4. 7.05	Sulman & Picard	Ore Concentration	Bubbles
788,247	25. 4.05	Cattermole, Sulman & Picard.	Ore Concentration	Soap and Flotation
777,274	13.12.04	Cattermole, Sulman & Picard.	Concentration of Minerals from Ores	Soap and Granulation
879,985	25. 2.08	H. L. Sulman	Separation of Metalliferous minerals from gangue	Table Flotation
835,120	6.11.06	Sulman, Picard & Ballot	Ore Concentration	Oleic Acid Froth
835,143	6.11.06	H. L. Sulman	Ore Concentration	Boiling
835,479	6.11.06	Sulman, Picard & Ballot	Ore Concentration	Superaerator
902,018	27.10.08	H. L. & E. A. Sulman	Ore Concentration	Buddle
955,012	12. 4.10	H. L. Sulman	Concentration of Ores	Alcohol
962,678	26. 6.10	Sulman, Greenway & Higgins.	Ore Concentration	Solution
953,746	5. 4.10	T. J. Hoover	Apparatus for Ore Concentration.	Froth apparatus with baffle
	6. 7.10	T. J. Hoover		Froth apparatus agitator as pump

Despatched

(Seal of Minerals Separation, Limited)

26—259

JAMES M. HYDE.

401

THIS PAGE BOUND VERTICAL IN BOOK

The Common Seal of Minerals Separation, Limited, was hereto affixed in the presence of—

S. GREGORY,
W. W. WEBSTER,
Directors.
A. O. WILLIAMS, *Secretary.*

(Seal of Minerals Separation American Syndicate, Limited)

The Common Seal of Minerals Separation American Syndicate, Limited, was hereto affixed in the presence of—

JOHN BALLOT,
FRANCIS L. GIBBS,
Directors.
A. O. WILLIAMS, *Secretary.*

(Acknowledgment.) (727—8)

813 COMPLAINANTS' EXHIBIT ABSTRACT OF TITLE.

Instrument Dated Dec. 7, 1909. Recorded Aug. 28, 1911, Lib Y 87, Page 80.

Parties:

Henry Livingstone Sulman, H. F. K. Picard, John Ballot, Minerals Separation, Limited, 63 London Wall, London, England.

Invention:

Ore Concentration. Nov. 6, 1906. 835,120.

These Assignors, stating that they own said letters patent, and all rights thereunder, assign the whole right, title and interest in said invention and letters patent. Consideration $1.

COMPLAINANTS' EXHIBIT CHAPMAN REPORT, AUGUST 16, 1907.

The Sulphide Corporation, Limited.

Central Mine, Broken Hill, N. S. W.

August 16th, 1907.

Theodore J. Hoover, Esq., Manager Minerals Separation, Ltd., London.

DEAR SIR:

Zinc Corporation, Ltd.

On Mr. Courtney's last visit to Broken Hill he instructed me to report briefly on the working of the Granulation Process on the British Mine.

814 Mr. Huntley's Regime.—Dating back to the time when Mr. Huntley was superintendent of the Zinc Corporation's Broken Hill Works, I was taken over the Potter Process Plant erected under Mr. Queneau's instructions and according to his ideas. Mr. Huntley was very anxious to (728—9) try this plant with a little oil added to the agitation without addition to the plant. I did not give much encouragement to this proposal, and finally Mr. Huntley arranged for a nest of agitators of our box type, together with spitz box separators of our pattern. Work was then started with very encouraging results.

The plant was very weak in its feeding and crushing stages, and I constantly advised that attention to the crushing department was quite as important as to the treatment section. Some attention was being paid to this until instructions were given that the plant was to be run to test tonnages and grade of concentrates. The feed to plant was therefore rushed and exceedingly irregular, but high grade concentrates were recovered.

The increase of tonnage determined the weak points of the plant after several weeks of annoying petty stops due to bad methods of elevation and insufficient boiler plant.

Operations Under Mr. Mitchell's Supervision.

It was at this time that Mr. Mitchell assumed charge of operations and various changes of the staff occurred. Again I emphasized the importance of crushing with regular feed of both grainy
815 material and slimes produced from crushing. I was told that the plant was merely an experimental one, and it was to be run only for tonnage and grade of recovered concentrates. The management were aiming at 500 tons per day and a 46% Zn.

High Tonnages.

This mad desire for tonnage irrespective of recovery became the object of foremen and shift bosses, and nothing was left undone

to produce good tonnage. The breakages to plant caused delays of 8 to 12 (729—10) hours per day (average), so that when plant was running it was rushed to such an extent that it was hardly worth putting the crude tailings through the crushing section.

Treatment Without Crushing and Irregular Feed.

Besides the feed from crusher section, an incline tramway and conveyor belt delivered current British Mill, Wilfley and Card table tailings, together with old dump slimes to the treatment section. As regards size this feed was quite amenable to treatment, but here the worst irregularities of the feed occurred. As trucks came up the inclined tram they were tipped into a hopper directly over the inclined belt. This feed to plant would last a few minutes only, and while the trucks were being returned and loaded, no feed from this source was delivered to the treatment section. I estimate that the belt was delivering feed for treatment 20% of its time, and the remainder of the time no feed was going
816 to the agitators from this source. There is no need to state how difficult it was to regulate the acid and oil feeds to ensure successful work.

This was partially remedied by the introduction of one 5 ft. agitator which delivered its agitated pulp to the mixers for treatment.

At the time when the matter of tonnages was obviously very critical (the reason not being disclosed) shift bosses on several occasions had current British Mill jig tailings (uncrushed) tipped as Card and Wilfley tailings. As this was going on unchecked I called the attention of the officials to this underhand method of getting high tonnages. They promised to have it stopped, but this (730—11) abuse continued. I, therefore, reported the matter to Mr. Mitchell, who promised that it should be stopped, and on making other visits to the plant I saw that it continued, with or without the superintendent's knowledge. I would add that the tailings from the jigs at British Mill are product of 3 m/m. crushing and assay from 12% to 14% Zn.

Slimes from Crushing.

The regular feed of slimes produced from crushing along with the grainy material was a matter that I claimed had to be seen to early. No definite line of work, however, was agreed upon, but the management were getting interested in this proposition when the plant shut down.

Size of Feed.

This should have been reduced to ½ m/m. and below, whereas sizing tests made gave 33% of the total feed over ½ m/m. This oversize often reached 50% of the feed, and was composed of
817 jig tails from the dump, and jig tails direct from British Mill, the tails from the Card and Wilfley tables that were treated being of a sufficient fineness not to require further crushing.

Results.

In spite of these adverse conditions, a very high grade zinc product was being produced and shipped, and satisfaction was expressed by those in charge.

When the 500 tons per day limit had been reached and the plant was running smoothly, I again suggested that more attention be paid to crushing to ensure higher recoveries. Mr. Mitchell then expressed the opinion that finer crushing would not give better results, and, no doubt, reported the same to his Board.

I was certain that this was the remedy of the (731—12) trouble, and was glad to know that the plant was to be given over to work on our own crushing lines for a definite period.

As you know, when negotiations were being made the plant was shut down without notice.

Yours faithfully,

GEO. A. CHAPMAN.

COMPLAINANTS' EXHIBIT HIGGINS REPORT, JANUARY 4, 1911.

2, KING JOHN'S COURT, E. C. 4th Jan., 1911.

Messrs. Minerals Separation Limited, 62, London Wall, E. C.

DEAR SIRS:

Re "Tecolotes Slime Tails."

The tests made on this ore show that it is amenable to
818 treatment although low in metallic values; for this reason a high recovery cannot be expected. The grade of the concentrates in zinc is good, especially in test No. 220 where no acid was used. The limit of the zinc assay in the concentrates calculated from the figures given is 44.5%. In my opinion the bulk of the insolubles in the concs. resulted from the 2nd and 3rd treatments where only small bulks were obtained, so that by eliminating these a higher grade concentrate should be obtained with a slightly lower recovery, unless the 2nd and 3rd conc. were retreated.

It is noteworthy that the grade of the concentrates obtained by the use of Turpentine (Russian) is almost as good as that from the use of oleic acid with 90 lbs. of (732—13) sulphuric acid, further, that Turpentine in cold circuit (12° C.) was almost useless, which may have been due to the oxidation in drying the sample before it was sent to you.

I am, dear Sirs,

Yours faithfully,

A. HOWARD HIGGINS.

6 encls. (733—14)

COMPLAINANTS' EXHIBIT FROMENT DESCRIPTION.

Description et instructions pour la concentration des minerais.

A. Description.

Le matériel se compose:
1° d'un malaxeur centrifuge
2° d'un cuve à serpentin
3° d'un crible d'épuration hydraulique avec extracteurs (si cela est necessaire)
819 4° d'une caisse à filtre

La légende que accompagne le déssin donne déjà une idée assez complète du matériel, il en est de même du matériel d'essai.

Néanmoins, nous donneront, quelques reinseguements supplémentaires.

A. Le malaxeur centrifuge se compose d'un corps cylindrique en tôle forte rivée avec boulons, et dans laquelle deux agitateurs marchent en sens inverse à raison de 300 tours environ par minute.

Le minerai est versé on arrivé par la petite auge située sur le coté, et l'huile est ajoutée par un petit tube situé à coté.

(Observations.) La malaxeur d'éssai peut traiter environ 2 Kil. ½ de minerai par charge. On doit faire tourner les agitateurs au fur et à mesure que l' on verse le minerai avec l'eau et le calcaire.

Pour 2 Kil. ½ de minerai il faut environ 6 litres d'eau. Tourner pendant quelques minutes, puis évacuer le minerai en tournant toujours.

B. La cuve à serpentin peut être construite en bois. Il en faut deux par malaxeur pour alterner les charges. Pendant que l' une est en travail, l'autre se (734—15) remplit. Chaque cuve doit contnir environ de 200 à 400 Kilos de minerai. Cela est affaire de practique. La hauteur est d' environ 0 m. 50 sur un diamètre de 1 m. 70 suivant la densité du minerai à traiter.

Un serpentin en plomb occupe le fond de la cuve. Ce serpentin est troué, les trous sont en dessons pour éviter qu'ils ne se bouchent pas. Le tube remontant du serpentin se divise en deux
820 branches, l'une destinée a recevoir la portion d'acide sulfurique nécessaire; l'autre, pouvant, si celà est nécessaire, etre reliée á un générateur de vapeur. La vapeur, sous faible pression, arrive par les trous du serpentin et active les réactions.

Cele est seulement nécessaire dans les pays froids. Dans le cas où cette branche ne sert pas à la venue de la vapeur, elle peut, avec avantage, remplacer le tube à eau dont il va être parlé. (Dans le matériel d'essai cette chandiére a été laissée.)

Un tube à eau sans pression, mais avec robinet, doit venie déboucher, à 0 m. 45 du fond, de façon a permettre l'evacuation des sulfures qui montent à la surface. Ce tube est inutile si l'on veut écumer ces sulfures où les pousser avers l' auge d' évacuation. Il peut être remplacé par une des deux branches du serpentin.

Un rateau horizontal tourne lentement dans la cuve, il se tourne

par un arbe vertical et une poulie; il doit faire 10 à 12 tours par minute.

C. Le crible d'epuration est constitué par un cadre en bois dur, sous lequel est fixée une plaque d'aluminium percée de trous de ½ millimètre. Ce cadre est soutenu par des montants en bois auxquels il est fixé (735—16) par des attaches a ecrou de façon à obtenir l'inclinasion nécessaire.

Les montants sont fixés à une cuve en bois dont la longeur est d'environ 2 M. 50, la largeur 0 m. 75. Le crible proprement dit en occupe presque toute la surface.

Le mouvement est donné par un éxcentrique mais il est nécessaire d'observer que les secousses doivent être nombreuses
821 avec peu d'amplitude, autrement le crible fonctionnera mal.

La caisse est percée de 3 trous pour l'évacuation des résidus et ces trous correspondent à 3 divisions de la caisse. Un tube supérieur de décharge déverse les parties légères dans la caisse à filtre.

Le déssin montre 3 extracteurs pointus pour une extraction continue. Mais, dans ce cas, il faut beaucoup d'eau. Un tube à eau, sans pression, mais avec robinet, entre vers le milieu de la caisse du crible amenant doucement l'eau necessaire pour tenir toujours le crible sous l'eau.

D. La caisse à filtre est faite en bois, elle a les dimensions que l'on veut bien lui donner; il n'y a pas à cet égard, des mésures précises. Elle est garnies de filtres doubles en toile avec poussier de charbon. Au travers de ces filtres l'eau s'écoule et les sulfures sont retenus.

B. Instructions.

L'expérience a prouvé que pour arriver à la parfaite désintégration des particules constituantes du minerai sans pour cela faire de l'impalpable, le broyage doit se faire en deux fois. Le première fois, le minerai (736—17) broyé doit passer a tràvert d'un tamis No. 15, soit dans un moulin à boules, soit dans un moulin Griffin on autre. La seconde fois il doit passer dans un tamis 128 environ et le broyage sera fait par un moulin Huttington, boccard, etc.

La production est beaucoup plus grande par voie séche que par voie humide, mais il ya a plus d'impalpables. A sa sortie du second moulin, le minerai sera donc soumis à 2 ou 3 spitzkas-
822 ten pour éliminer la portion de schlammes trop fins pour être traités et qu'aucune méthode n'a pu traiter jusqu'ici. Dans l'état de grosseur où il doit se trouver, le minerai arrive avec un peu d'eau dans le malaxeur centrifuge toujours en mouvement. Lorsque l'on juge que la quantité de minerai est suffisante (environ 2 à 300 kilos) pour constituer une charge, on ajoute 1% environ de carbonate de chaux, 2% au maximum dans les cas difficiles, et environ 1 à 1½% de huile minérale à machine. On laisse le malaxeur agir pendant 10 minutes environ, l'essentiel est que tous les grains de sulfures soient bien touchés par l'huile.

(Observation.) Si la teneur du minerai dépasse 5% de matières

métalliques, cuivre, plomb, il faudra ajouter un peu plus d'huile. En thèse générale on peut compter;

1	%	huile pour	jusqu'a	5%	de métaux
1½	%	"	"	10%	"
2	%	"	"	15%	"

Il est rare que l'on ait à enrichir des minerais contenant plus de 15% de cuivre. Dans nos contrées: Italie, France, Espagne, un minerai à 15% de métal cuivre est considéré comme riche et traité tel quel. Pour les (737—18) minerais de plomb, on enrichit jusqu'a 60% de plomb, il est rare que l'on aille au Dela.

En conséquence, pour un minerai plombeux d'une teneur de 20% il faudra 2% huile.

2°	Pour une teneur de	30%	2½%	huile
3°	" "	40%	3%	"
4°	" "	50%	3½%	" etc.

Il est logique de penser que le carbonate de chaux suit à
823 peu près une même proportion puisqu' il faudra davantage de gaz pour un minerai riche que pour un minerai pauvre. La dépense est donc proportionnelle à la richesse du minerai et par conséquent proportionnelle à la teneur du concentré obtenu. Le procédé en question trouve mieux son application dans le traitement des minerais pauvres que dans ceux des minerais riches. Il serait parfait, par éxample, pour reprendre et traiter les stériles et les ½ mixtes, résidus des laveries ordinaires, surtout lorsque ces laveries ont en à traiter des minerais difficiles. Quoiqu' il en soit, après le malaxage centrifuge, le minerai est déversé, le malaxeur étant toujours en mouvement dans la cuve à serpentin.

Pendent que le malaxeur s'éxonère de sa charge de minerais dans la cuve, l'agitateur dont celle-ci est munie est mis en moúvement à raison de 10 à 12 tours par minute, de facon à ce que le minerai ne puisse se rassembler au fond en masse trop compacte.

L'acide sulfurique est versé par le tube de plomb qui sert à cet éffet. Il est bon de diluer cet acide à 30° Baumé par example. La cuve doit être remplie d'eau jusqu' à la hauteur du déversoir. Le tube de plomb qui sert à l'introduction de l'acide dans la. (738—19) cuve est à 2 branches, dont l'une, munie d'un robinet, peut à volonté laisser venir, ainsi que nous l'avons déjà dit, de la vapeur ou de l'eau. La quantité d' acide varie avec la quantité de carbonate de chaux, elle est proportionnelle a cette dernière, c'est-à-dire qu'il faudra environ 1% d' acide à 66° Baumé pour 1% de carbonate de chaux lequel est, on l' a vu, proportionnel comme l'huile à la
824 quantité de sulfures. Tout aussitôt que l'acide est parvenu dans le recipient et qu' il a commence à se mêler avec le minerai, la réaction commence de suite et la plus grande partie des surfures gras monte à la surface entrainée par les bulles de gaz. Ils sont écumés ou poussés dans la petite auge qui sert de deversoir au récipient.

Une petite partie retombe et se mèle à la gangue, mais, des l'instant que les particules sulfureuses de cette partie ont été bien touchées par l' huile, elles se separéront facilement dans le crible d'epuration auxquelles elles seront tantôt soumises.

Lorsque la réaction est terminée c'est à dire lorsque'il ne monte plus de bulles de gaz accompagnées de sulfures au dessus du liquide, le residu composé de la gangue et d'une faible partie de sulfures qui y sont restées, est amené peu à peu sur le crible d'épuration.

Ce crible doit travailler par petites secousses, environ, 200 par minutes, secousses sèches et sans amplitude. L' éxcentrique du crible d'éssai donne difficilement de ces secousses très répetées et cela se comprend. Il faut proceder par tatonnements.

Dans la partie industrielle le mouvement de ce crible sera donné par un appareil très simple, dont croquis A sur feuille séparée. (739—20)

Par suite des secousses, la matière se répand uniformént en une couche mince sur le crible; les parties sulfurées grasses montent au dessus, gagnant ainsi l'extremité du crible, tandis que la gangue passe au travers la portion lourde en tête.

L' eau qui s'écoule par le déversoir du crible passe dans une caisse à filtre retenant les parties sulfureuses qui pourraient surnager.

Dans les appareils d'éssai, cette caisse à filtre n'éxiste pas. Il est facile de recevoir l'eau d'écoulement dans un vase quelconque percée d'une ouverture basse munie d' un filtre.

Si l'operation a été bien conduite, il ne doit plus rester de parties sulfureuses dans la gangue, sauf de la pyrite de fer.

Les concentrés peuvent être soumis à la presse hydraulique ou au filtre-presse et par cette opération, I'on peut récupérer une très grande partie de l'huile. (740—21)

COMPLAINANTS' EXHIBIT TRANSLATION OF FROMENT DESCRIPTION AND DESCRIPTIVE MATTER ON FROMENT DRAWINGS.

29th December, 1903.

Description and Instructions for the Concentration of Ores.

A. Description.

The machinery comprises:
1. A centrifugal mixing device.
2. A vat with coil.
3. A hydraulic purification screen, with extractors (if necessary).
4. A filter case.

The explanatory writing on the drawing already gives a fairly complete idea of the machinery, the same applies to the experimental machinery.

Nevertheless, we will give a few supplementary explanations.

826 A. The centrifugal mixing device is composed of a cylindrical body, made of string sheet iron riveted with bolts, in which two stirring devices work in opposite directions, making about 300 revolutions per minute.

The ore is charged, or arrives, through a small hopper or shoot arranged at the side, and oil is added through a small pipe arranged at the side.

(Remarks.) The experimental mixing device is capable of treating about 2½ kilograms of ore per charge. The stirring devices must be made to rotate as ore with water and limestone are introduced.

For 2½ kilograms of ore it is necessary to have about 6 litres of water. Set the ore to rotate in the apparatus for a few minutes, then discharge the ore without stopping the apparatus: (741—22)

B. The vat with coil can be made of wood. Two such vats are required for each mixing device, in order to alternate the charges. While one is working, the other is being filled. Each vat must contain about 200 to 400 kilograms of ore. This is a matter of practice. The depth is about 0.50 metre and the diameter 1.70 metre, according to the density of the ore to be treated. A lead coil occupies the bottom of the vat. The coil in question is perforated, the holes are underneath, to avoid their getting clogged. The tube rising from the coil, is divided into two branches, one intended to receive the necessary quantity of sulphuric acid and the other, if considered necessary, can be connected to a steam generator. Steam at low pressure arrives through the holes of the coil and assists the reaction. This is only necessary in cold countries.

827 In case the branch in question is not used for supplying steam, it can advantageously replace the water pipe hereinafter described. (This boiler was left in the experimental machinery.)

A pipe containing water without pressure, provided with a valve, must merge about 0.45 metre from the bottom, so as to enable the sulphides rising to the surface to be discharged. This pipe is unnecessary if it is desired to skim these sulphides or to push them towards the discharge hopper. It can be replaced by one of the two branches of the coil.

A horizontal rake turns slowly in the vat, it is operated by a vertical spindle and pulley; it must make 10 to 12 revolutions per minute.

C. The purifying screen is constituted by a frame made of hard wood, under which is fixed an aluminum plate (742—23) provided with holes of ½ millimetre. The frame in question is supported by wooden uprights to which it is secured by brackets with nuts, so as to obtain the necessary inclination.

The uprights are secured to a wooden vat, the length of which is about 2.50 metres, the width 0.75 metres. The screen proper occupies nearly the whole of its surface.

The movement of the screen is effected by means of an eccentric but it must be pointed out that the shocks must be numerous and of small amplitude, otherwise the screen will not work well.

The case is provided with three holes for the discharge of the residues, and these holes correspond to the three compartments of
528 the case. An upper discharge tube discharges the light substances into the filter case.

The drawing shows three pointed extractors for continuous extraction. But in that case, a great deal of water is required. A water pipe, without pressure, provided with a valve, merges into the case about its center and slowly supplies the water required to keep the screen submerged the whole time.

D. The filter case is made of wood it may be made of any desired dimensions—no definite measurements need be complied with in that respect. It is provided with double filters of canvas with charcoal powder in between. Water can pass through these filters, while the sulphides are kept back.

B. Instructions.

Practical experience has shown that, in order to arrive at a perfect disintegration of the constituent (743—24) particles of an ore, without rendering it impalpable, it is necessary to do the crushing in two operations. The first time the crushed ore must pass through a sieve No. 15, either in a ball crusher mill or in a Griffin Mill or any other. The second time, it must pass through a sieve of about 120 and the crushing would be effected in a Huntington Mill, stamp mill, etc.

The output is much greater by dry process than by wet process, but there is a greater proportion of impalpable particles. On leaving the second crushing mill, the ore will therefore be submitted to two or three "Spitzkasten" for eliminating the slime which is too fine to be treated and which could not be treated by any
829 hitherto known method. Reduced to the size which it ought to have, the ore arrives with a little water into the centrifugal mixing apparatus which is always working. When it is thought the quantity of the ore is sufficient (about 200 to 300 kilograms) to constitute a charge, about 1% of carbonate of lime, maximum 2% in difficult cases, and about 1% to 1½% of mineral engine oil are added. The mixing apparatus is left to work for about 10 minutes, the chief point is that all the sulphide grains should come into thorough contact with the oil.

(Remark.) If the ore contains more than five per cent of metallic matter, such as copper, lead, it will be necessary to add a little more oil. As a general rule, one may assume;

1	% of oil for	ore	containing	up to	5%	of metals.
1½%	"	"	"	"	10%	"
2	% "	"	"	"	15%	"

It is very rare that one has to enrich ore containing (744—25) more than 15% copper. In our countries, Italy, France, Spain, ore, containing 15% of metallic copper, is considered very rich and is treated as such. In case of lead ore, concentration is continued until the ore contains 60% of lead, this later proportion is seldom exceeded.

Consequently for a lead ore containing 20% of metallic matter, it will be necessary to use 2% of oil.

2. For ore containing 30% of metallic lead 2½% of oil.

3. For ore containing 40% of metallic lead 3% of oil.

830 4. For ore containing 50% of metallic lead 3½% of oil, etc.

It seems reasonable to assume that the proportion of the carbonate of lime follows practically the same rule, for a richer ore will require more gas than a poorer one.

The expenditure is, therefore, in proportion to the richness of the ore and, consequently, in proportion to the metallic matter contained in the concentrated ore obtained. The process in question is more suitable for the treatment of poor ore then for that of rich ore. It would be perfect, for instance, for taking up and treating sterile ore and ½ mixed ore, residues obtained from the ordinary washing apparatus more particularly when the washing apparatus in question had to treat difficult ore. However this may be, after the centrifugal mixing, the ore is discharged into the vat with coil, the mixing device being always in motion in the vat with coil.

Whilst the mixing device is being emptied of its charges of ore into the vat, the stirring device, with which the latter is provided, is started at the rate of 10 to 12 revolutions per minute, so as to prevent the ore from collecting at the bottom in too compact a mass. Sulphuric acid is introduced through the lead pipe which (745—26) serves for this purpose. It is advisable to use for the purpose sulphuric acid diluted to say 30° Baume. The vat must be filled with water up to the level of the overflow. The lead pipe which is used for introducing the acid into the vat, has two branches, one of

831 which, provided with a valve, can be used to admit whenever it may be necessary steam or water, as already stated. The quantity of the acid varies with the quantity of the carbonate of lime, it is in proportion to the latter, that is to say, it will be necessary to use about 1% of acid at 66° Baume for 1% of carbonate of lime, which, as already stated, is, like the oil in proportion to the quantity of the sulphides. As soon as the acid has reached the vessel and begun to mix with the ore, the reaction will at once begin, and the greatest part of the greased sulphides will rise to the surface, carried by the gas bubbles. They are skimmed or pushed into a small hopper which forms an overflow for the vat.

A small proportion falls back and gets mixed with the gangue, but the moment the sulphurous particles of that part come into thorough contact with the oil, it will be easy to separate them in the purifying screen in which they would be subsequently treated.

When the reaction has been completed, that is to say when no more gas bubbles, accompanied by sulphides rise to the surface of the liquid, the residue consisting of the gangue and of a small proportion of sulphides that have remained in it, is gradually brought to the purifying screen.

This screen must work by small shocks, about 200 per minute, these shocks must be "dry," that is to say sudden, (746—27) and without amplitude. It has been found difficult to produce such

repeated shocks by means of the eccentric of the experimental screen, which can be easily explained. It is necessary to proceed
832 by groping.

When using it on a large scale, the screen will be caused to shake by a very simple apparatus, a sketch A, of which is given on a separate sheet. Owing to the shocks, the material spreads uniformly on the screen in a thin layer. The greased sulphurous parts rise upwards, thus arriving at the extremity of the screen, while the gangue passes through the heavy portion at the head.

Water escaping through the overflow of the screen, passes into a filter-case retaining any sulphurous particles that might come to the surface. In the experimental apparatus, this filter case *not does* exist. It is easy to collect the escaping water into any vessel provided with a hole at a low level, provided with a filter. If the operation has been properly carried out, no sulphurous parts should remain in the gangue, except iron pyrites.

The concentrated ore may be subjected to treatment by a hydraulic press or filter press, and by that operation a very large proportion of the oil used can be recovered.

Sketch A.

1. Iron Vibrator.
2. Spindle.
3. Spring.
4. Eccentric.
5. Iron bracket to be fixed to the vat.
6. Counter-shock mounted on the vat.
7. Partitions.
8. Overflow. (747—28)

833 9. Flexible iron stop.
10. Screen.

Large Drawing.

A. Centrifugal Mixing Device.

1. Pulley.
2. Driving shaft, 60 rev. minute.
3. Large gear.
4. 4′. Gears driving the stirrers 300 revs/min.
5. Hopper for charging in ore coming from the crusher.
6. Safety (overflow) pipe discharging into any vessel.
7. 7′. Vessels receiving the ore after the centrifugal mixing.
8. 8′. 8^2. Iron frame supporting the mixer.
9. 9′. Water pipes with valves for expelling the ore from the vessels, 7 and 7′ and introducing it into the coil vat.

B. Coil Vat.

1. Vat proper made of wood.
2. Table supporting the vat.
3. Overflow discharging sulphides into the filter case.
4. Pulley and shaft driving the rake in the interior.

5. Discharge tube for the residue.
6. Drain pipe for the coil.
7. 7′. Two-branch tube of the coil.

C. Purifying Screen.

1. Screen case.
2. Water pipe with valve used, when necessary, for maintaining the case always full of water.
834 3. Pulley and shaft driving the screen.
4. 4′ 4². Supports of the screen. (748—29)
5. Aluminum screen, wood mounted.
6. 6′ 6″. Discharge pipes for the residue.
7. Discharge pipe for the light sulphides falling into the filter case.
8. 8′. 8″. Residue in extractor, for the case that it is desired to classify it.

D. Filter Case.

1. The case proper.
2. 2′. 2″. 2‴. Canvas filters consisting of a wooden frame with canvas stretched on both sides.
Between the two canvases is contained charcoal powder.
4. Emergency discharge pipe. (749—30)

COMPLAINANTS' EXHIBIT FRYER HILL PUBLICATION.

(The "Daily Herald Democrat," Leadville, October 30, 1889.)

An Important Invention.

Experiments with the Oil Rotary Concentrator.

One of the most novel methods of treating dry silicious ore ever brought to notice—An exhaustive review of the new process—Its advantages particularly applied to the miners of Fryer Hill—News from the mines—Shipments from the new quartzite strike—Mikado's new developments.

Experiments are now being made in Denver with a new appliance for the concentration of dry silicious ores, such as those of the Dunkin, Matchless, Little Silver, and in fact all the mines of Fryer Hill. So far, the experiments have proved a perfect success,
835 the tailings from the concentrator, if so it may be called—only running one ounce to silver from a crude ore that ran over ten ounces of silver per ton. The first unimportant means of testing the new system having proven so incontestably the correctness of the theory, other larger and more capable means have been employed. The whole system of concentration appears to be based on the well known affinity of the lighter forms of sulphuret and chloride of silver for oils. Petroleum is the oil now being used by the parties having these experiments in charge, and appears from its density, to possess the requisite adhesiveness to effect the result desired. The ore is first crushed and rolled to such a degree of

fineness as to enable it to pass through a 40 mesh screen, and while dry, is thoroughly mixed with the oil, after which it is placed in a circular (750—31) tank or receiver, through the center of which runs a rotating hollow tube, to the bottom of which tube is attached, on two opposite sides, a couple of fans, the lower edges of which are unevenly cut in order to send—in the revolution—the lighter particles of the ore and oil mixture to the outer sides of the drum or cylinder. This rotating hollow tube is perforated at, or near, the bottom, and, when the receiver is thoroughly charged, acidulated (sulphuric acid is used) steam is introduced through the tube and is forced to the bottom of the mixture, while the ar-astre-like fans, attached to the bottom of the tube, keep the whole mixture in motion, and the action of the revolving tube, the fans, and injected acidulated steam causes the lighter portions of the mineral-charged
836 oil to float to a point just above the center of the receiver, where there are suspended two semi-circular doors, which when the oil has passed above them, laden with its precious freight, are raised, and the superfluous water allowed to drain through slight perforations in the bottoms of these semi-circular doors, after which the mineral-laden oil is carefully removed to settling barrels revolving with jets of steam injected continuously from the lower ends These settling barrels being placed at an angle, permit the mineral laden oil to pass through openings in the ends, which are connected with shallow settling tubs or tanks from which the concentrated ore is shipped directly to the smelters, who will hardly be likely to refuse so pleasant an addition to their heating powers. As said above, with the present plant, which is daily being improved upon, a good, high grade concentrate is being (751—32) made on ores on which no previous methods of saving the silver value has proven entirely satisfactory, and the few mining men of Fryer to whom this scheme has been whispered are watching the experiment with a great deal of interest, as there are thousands of tons of such ore now awaiting treatment.

COMPLAINANTS' EXHIBIT CRILEY & EVERSON PUBLICATION.

No. 15, 1890—581.

The Engineering and Mining Journal, Oregon, Baker County.

BAKER CITY, Nov. 10.

Quite a number of capitalists from Portland and Walla Walla are here watching the result of some test-working of the "Criley & Everson Oil Process" for the extraction of sulphurets from any ore as the name signifies by the use of oil. Your correspondent witnessed a test made on the Eureka and Excelsior ore, which was conducted as follows: The ore was crushed and passed through a 50 mesh sieve, weighed and thoroughly mixed with black thick oil. To water heated to near boiling was added enough suphuric acid to give it a tartish taste. This acidulated water was then mixed with the mass of oil and ore. A thick scum of sulphurets rose to the surface and was skimmed off, leaving the hitherto black ore

as white as snow—in fact, pure silica. The gentlemen expressed themselves as pleased and the citizens of Baker County are in hope they are, because it means the erection of a large plant at
837 this point. (752—33)

838 COMPLAINANTS' EXHIBIT STATEMENT OF PROFIT LAZARD VENTURES.

Statement of Profits Made by Ventures a/c by Treatment of Material in Minerals Separation, Ld., Tailings Plant with Agitation-froth Process.

	Total.	Lazard Bros.	M. S., Ld.	S. C., Ld.
Original Joint Venture.....	£130,341– 8–10	£65,170–14– 5	£65,170–14– 5	
Triple Venture ...	51,024–11–11	12,756– 3– 0	12,756– 2–11	£25,512– 6–0
South Blocks Venture.....	321– 5– 0	160–12– 6	160–12– 6	
Total.....	£181,687– 5– 9	£78,087– 9–11	£78,087– 9–10	£25,512– 6–0

HCH.
3/9/12

(753—34)

COMPLAINANTS' EXHIBIT TABLE OF MATERIAL AND RESULTS LAZARD VENTURES.

Table of Material Treated and Results Obtained in Minerals Separation Tailings Plant with Agitation-froth Process.

Period.	Material.	Feed concentrates. Tonnage.	Produced tons.	Realized value.
Original Joint Venture:				
November, 1907, to September, 1910.....	Dump Tailings.....	481,859	170,290	£506,417
Triple Venture:				
September, 1910, to April 1911.....	Dump Tailings.....	50,000	14,073	
	Magnetic Tailings...	65,682	17,316	93,419
Joint Venture (South Blocks):				
April, 1911, to June, 1911	Middlings	39,258	14,502	35,535
Total.....		636,799	216,181	£635,371
839 **Costs:**				
Paid for Tailings, per ton.....	Tails.....	5.04	£160,553	
Total Cost of plant Management, Treatment, Interest, Realization, etc., (everything included)	do.	9.20	£293,130	£453,683
Net profit.....	do.	5.71	.....	£181,688

HCH.
8/8/12

(754—35)

COMPLAINANTS' EXHIBIT STATEMENT OF EXPENDITURES IN AGITATION-FROTH PROCESS.

Statement of Expenditure Incurred by Minerals Separation, Ld., in Introducing the Agitation-froth Process to 31 *Dec.*, 1911.

Plant and Laboratory Apparatus		£9,317- 1-2
Experimental & General Expenditure:		
Management, Traveling Staff, Examination of Properties at Home and Abroad		62,115-16-5
London Administration:		
Office Salaries & Rent	£5,569-17-11	
Legal Charges	1,027- 7-	
Audit Fees	177-19- 6	
General Expenses	3,428- 6- 5	
Postages and Cables	2,193-13- 9	
Interest	320-11- 9	
Directors' Fees	7,378-14- 8	
		20,096-11-
		£91,529- 8-7

HCH.
4/8/12

Note.—The expenditure incurred in Purchases of Patents, Patent Fees & expenses & Patent Litigation and amounting in all to £55,481-0-10 is not included in the above statement. (755—36)

840 COMPLAINANTS' EXHIBIT STATEMENT OF EXPENDITURES BY AMERICAN SYNDICATE IN AGITATION-FROTH PROCESS.

Statement of Expenditure by Minerals Separation American Syndicate, Ld., in the Introduction of the Agitation-froth Process to 31 *July*, 1912.

(1) Into United States of America	£12,360-15-5	
(2) Into Mexico	1,401-16-8	
(3) Into Canada	1,433- 9-7	
		£15,196-1-8

HCH
2/9/12

The above statement does not include any litigation expenses or any of the Costs in the present suit. (756—37)

841 COMPLAINANTS' EXHIBIT STATEMENT OF TONNAGE TREATED BY AGITATION-FROTH PROCESS AT BROKEN HILL, AUSTRALIA.

Tonnage of Tailings & Slimes Treated by Minerals Separation Agitation-froth Process at Broken Hill, Australia, with Concentrates Produced as per Official Returns Made by Licensees.

	Tailings & slimes—Tons.	Zinc, lead, silver concentrates—Tons.
Sulphide Corporation, Ld. Part year ending 30th June, 1906, 30 June, 1912.	1,176,934	445,290
Mineral Separation, Ld. Jointly with Lazard Bros. & Co. & Sulphide Corporation, Ld., November, 1907 to June, 1911.	636,799	216,181
Zinc Corporation, Ld. Nov., 1910, to 30 June, 1912.	380,020	132,675
Broken Hill Junction North. Nov. 1911, to 12 March, 1912.	44,261	10,449
	2,238,014	804,604
Zinc Corporation, Ld. April, 1907, to Oct., 1910.	No returns of tonnage made but they paid £1500 in Royalties equivalent to 12,000 tons of Concentrates.	

HCH.
4/9/12

(757—38)

COMPLAINANTS' EXHIBIT STATEMENT OF PROFITS AND ROYALTIES ON AGITATION-FROTH PROCESS.

Minerals Separation, Ld., Proportion of Profits from Joint Ventures and Royalties Received from Licensees.

Original Joint Venture:		
Total Profit	£130,341– 8–10	
Minerals Separation, Ld., proportion ½		£65,170–14– 5
Triple Venture:		
Total Profit	51,024–11–11	
Minerals Separation, Ld., proportion ¼		12,756– 2–11
South Blocks Venture:		
Total Profit	321– 5	
Minerals Separation, Ld., proportion ½		160–12– 6
Total M. S. Ld., Profit		£78,087– 9–10
Royalties received from Licensees as far as accounted for and received in London to 30 June, 1912		£75,166– 0– 6
		£153,253–10– 4

(Royalties due but not yet paid or received in London at 30 June, 1912, are excluded.)

(758—39)

842 COMPLAINANTS' EXHIBIT TABLE OF SULPHIDE CORPORATION OPERATIONS WITH AGITATION-FROTH PROCESS.

Tonnage Treated	1,176,934 tons
Concentrates Produced	445,299 tons
Total Value	£1,154,353.
Per ton Feed	
Shillings	
19.6/–	
Less Total Cost of treatment	£504,200.
8.5/–	
Profit, 11.1/–	£650,153.

COMPLAINANTS' EXHIBIT SULMAN & PICARD REPORT, MARCH 25, 1903.

Sulman & Picard, 44 London Wall, E. C.

25th March, 1903.

John Ballot, Esq., Salisbury House, E. C.

DEAR SIR: As you are aware we have carried out numerous experiments on the Cattermole process during the past 2 months, the work done being mainly of a preliminary experimental character with a view towards getting a knowledge of some of the chief factors involved.

Whilst we were feeling our way much of the work done was not of a quantitive nature and therefore (759—40) no detailed records were necessary. Of late however work done has been
843 strictly quantitative and a schedule of results is appended hereto. It will be perhaps the most convenient way if we here state the general results arrived at from the whole series of qualitative and quantitative tests without considering each test separately. Firstly, we have endeavored to reduce agitation i. e. flocculating, breaking down, and rolling or agglomerating actions, to a mechanical standpoint and therefore have used the Gabbett cone and a mechanically rotated cylinder for all the later agitations required.

We early got away from the alkaline soap method of breaking down the first product resulting from the treatment of an ore with soap and oil emulsion by means of which the whole of the ore is precipitated from the milling waters as one uniform flocculent precipitate. This flocculating operation remains much the same as schemed by Cattermole originally. The next portion of his invention was to "break down" the flocculent precipitate into clean gangue and fine particles of oiled mineral by more or less violently agitating the flocculent precipitate with weak soap and alkali. By rolling or agglomerating the product so obtained the oily particles of mineral are made to cohere into gradually increasing shot-like granules, when they become sufficiently dense to be separable from

the coarse clean sands or gangue by the action of an upward current of water.

The combined minerals in the form of clean granules may then undergo further separation into their (760—41) constituent minerals by the application of solutions of increasing strength in alkali.

Our work up to the present has been confined entirely to
844 Broken Hill sulphide ores. This is a type of mineral which gives the greatest difficulty in the separation of gangue from mineral; the gangue is exceedingly heavy consisting as it mainly does of garnet and rhodonite—its specific gravity being nearly twice that of quartz, and varying from 4.3 to 4.7; and thus very nearly approaching in density that of the blende contained in the mineral. There being no difficulty in the separation of blende from galena when once the separation of the two from the gangue has been effected, we have confined our investigation so far entirely to separating the gangue from the combined mineral.

* * * * * * *

Kerosene emulsion of 75% strength was used in the earliest experiments, and though this oil works well, and in the rolling operation (after breaking down) yields hard shotlike granules, it has the disadvantage of not taking up all the blende, leaving the sand and slimes somewhat dirty with unrecovered zinc sulphide. It has been found that the substitution of thick residuum oil for large portion of kerosene used in the emulsion gives quite clean sand and retains every portion of the blende; but thick oil seems to leave the granules somewhat more readily affected by air, giving rise to floating granules whenever a pulp in which they are contained is exposed to the air. Pure kerosene granules also do this to some (761—42) extent and we are not yet sure whether this may not be due to the acid breakdown as compared with the original alkaline
method; if so it is a difficulty which has to be overcome, as
845 there can be no doubt that the acid breakdown is five or six times as cheap as the original alkaline soap method. The obvious remedy is to keep the granules and sands after the rolling or agglomerating stage carefully covered by water during their transference into and below the surface of the water in the upcast separating apparatus, for which purpose an open launder should not be used; but possibly some form of submerged Archimedean screw feed might be used on a large scale.

Facts which have been established so far are broadly as follows: Sharp ore does not give such good results as a mixture of sharp ore with slimes, as the fine mineral particles in the latter exercise a potent effect in building up the hard shotlike granules desired, by supplying "filling material" without which the large oiled mineral particles could not become sufficiently coherent or dense. Again slimes containing mainly, or only, blendes, are not so suitable as those which contain their due proportion of fine galena, also, as blende is the mineral most difficult to take up by oil, and the first to be rejected in subsequent separations. It does therefore not form such good filling or cementing material for granules as does galena;

but with a fair proportion of the latter ("fines") there is no difficulty in getting the blende to do its proper share of cementing work in forming the granules. These factors are those which mainly have to be considered in the original (762—43) grinding of the raw ore. It becomes therefore obvious that when the mineral is ground to
60 or 70 mesh that all slimes produced should be kept
846 strictly associated with the coarser particles and that the slimes so produced should not consist exclusively of the more readily slimed blende but a fair proportion of galena slimes should also be present. Given these conditions the operation of the Cattermole process has become much simplified compared with the scheme originally put forward. It is sufficient to take the ore suspended in about three to four times its weight of water and to mix this to a uniform pulp in a suitable mixer preferably of the Gabbett type; to this suspension, while still in a state of agitation, the oil emulsion is added. The proportions requisite may vary somewhat and are shown in the schedule. Roughly speaking we have found that the oil addition equal to about 7% upon the mineral present in the ore is sufficient. A small amount of soap solution is also necessary to obtain good flocculation and it appears to aid in the uniform dissemination of the added oil emulsion through the pulp in the mixer. A very short period of agitation is necessary to effect complete flocculation of the whole of the mineral, which readily subsides, leaving clear water above, opalescent with the soap added. The tendency of our work has been to show that a very small amount of soap is necessary and we have continually cut this down, almost to the vanishing point; still a small amount of soap during flocculation appears to be advisable. The clear solution still containing this small amount of soap is run off from the flocculent precipitate and can be used perfectly well on the next lot of mineral
to be flocculated. The whole (763—44) of the oil added as
847 emulsion appears to be taken up by the ore, and none to remain in the opalescent but otherwise clear liquor. The flocculating precipitate is so open that it drains most readily from any remaining liquor which cannot be decanted. The flocculent precipitate may even receive a plain water wash with advantage. The mass is then put into about three to four times its own volume of very dilute sulphuric acid which may vary between the limits of 0.05% to 0.1%. Somewhat violent agitation is now required for a period of a few minutes; the time being dependent upon the efficiency of the agitation, and varying from 2 to 5 or 8 minutes, whereby the oil is released from the gangue and attaches itself exclusively to the mineral. The mass changes in color and becomes much lighter owing to the liberation of the pinkish-white gangue, but the mineral remains disseminated through this mass in extremely fine granules which require to be agglomerated by rolling treatment. It is however found advisable before such rolling treatment is given to pour off or decant at least half of the liquor resulting from the breaking down, and, with this, to include as much of the fine but now clean gangue slimes as possible as the presence of

very fine gangue slimes seems to interfere somewhat with the attaining of hard mineral granules. The pulp, which now consists of very fine oiled mineral particles dispersed through clean gangue from which the finest slime gangue has been separated, is placed in a cylinder and rotated about its horizontal axis at the rate of about 60 to 80 revolutions per minute (for a 4″ diameter cylinder) for about ten minutes. This gentle (764—45) rolling action has the
848 effect of making the mineral particles cohere and build up into the shot-like granules required. When these are found to be of sufficient size the rolling operation is stopped and the mass separated in any convenient or efficient upcast water separator. We have naturally not been able to try the experiments on a sufficiently large scale to give definite factors as to the amount of rolling travel requisite for the agglomerating in large scale plant. In a 4″ cylinder about 1,200 ft. of such rolling travel is necessary, but, with increasing quantities the "mass factor" we find, constantly tends to reduce the amount of rolling travel, and it will probably be much less than the amount mentioned when larger apparatus is employed. We are constructing a cylinder of 8″ in diameter and 2′ in length fitted on the interior with slotted partitions and with a continuous inflow and discharge which will enable us to get at such a figure far more exactly. Finally, it is not always possible in the upcast apparatus used by us on the laboratory scale to effect in one operation a sharp separation into absolute gangue on the one side, and clean granules free from gangue, on the other. Whilst the heavies granules come away quite clean and the lighter sands are easily eliminated, a middle portion is apt to be formed consisting of lighter mineral granules mixed with the heavier sands; and any attempt to treat this middle portion is apt to drive over some of the smaller mineral granules with the heavy sands. We thus find it best in tests with our present small laboratory apparatus (with which it is very difficult to obtain uniform con-
849 ditions (765—46) and therefore uniform sized granules) to pass our rolled product through the upcast apparatus at first with only a comparatively light up-current of water. This rejects the bulk of the gangue as light sands, but gives a product containing all the granules mixed with some heavy sands. If this second product be then given a short further rolling treatment the fine granules become much larger and agglomerated with the heavier granules, and this product is then capable of a ready separation from the remaining heavy sands in a sharp up-current of water.

It is obvious that many variations of such separation treatment are possible, and that with a little experience a very simple and efficient form of apparatus could be devised. Combinations of such apparatus could be placed in series to deal with the various sand and granule products without the necessity for a second rolling agglomeration, but up to the present the facilities at our disposal, and the small scale upon which alone it is possible to work in the laboratory, have prevented us from using any but the simplest plant. The chain of operations is therefore extremely simple.

Firstly. Suitable crushing of the ore as specified.

Secondly. Flocculating the pulps with a small amount of soap and oil emulsion in the proportions given using a fair proportion of thick oil to kerosene. (It is only necessary here to note that emulsions containing thick oil are rather more difficult to get completely "smooth" that is, free from unemulsified oil globules, (766—47) than with kerosene alone; but with a little care and experience a perfect emulsion of thick oil is obtainable).

Thirdly. Breaking down the flocculent precipitate by strong agitation with very dilute acid.

Fourthly. Gentle rolling to agglomerate the fine mineral particles into shot like globules.

Fifthly. The separation of granules from gangue in a water upcurrent.

We are, dear Sirs,

Yours truly,

SULMAN & PICARD.

Addendum to Report.

We omitted to state that in our last experiment, No. 6, a further simplification has been made which seems to promise well. The flocculating stage has been abandoned and .05 to .1% acid has been used direct for suspending the duly crushed ore in. The addition of "thick oil plus paraffine" emulsion has been made direct to this, and after a sufficient agitation period has been given to the mixture, the gangue is found to be free and clean whilst the mineral is disseminated through this in a state of very finely divided granulation. On pouring off the bulk of the acid liquor, together with any fine, clean slimes which it may contain, and rolling the remainder as usually excellent granulation has been found to occur. We are not yet sure how this treatment may act with finely ground mineral slimes containing much blende, but experiments are in course to determine this. S. & P. (767—48)

851 COMPLAINANTS' EXHIBIT SULMAN & PICARD REPORT, MAY 5, 1903.

Sulman & Picard, 44 London Wall, London, E. C.
May 5th, 1903.

John Ballot, Esq., 607, Salisbury House, London Wall, E. C.

DEAR SIR:

Cattermole Process.

We beg to report results of experiments on the above process.

Expt. No. 7. This test was made on Broken Hill ore ground to 60 mesh. 1000 grammes of ore was used in two lots of 500 grammes each, as the Gabbett mixer will not take more than 500 grammes, which portion was agitated with 600 cc. of 0.2% Sulphuric acid and

30 cc. of Soap emulsion. The emulsion was made up of 50% of oil and 2% Soap; the oil being a mixture of two parts of residuum and one part of paraffine.

This charge was agitated about 10 minutes, half the time with the baffle, and half without. The two charges were then mixed and submitted to the rolling process in the Gabbett (without baffle) for a period of three minutes. This treatment yielded satisfactory granules.

The charge was then put through an upcast separator to remove the light sands.

852 The heavier portion was rolled in a cylinder, especially made for the purpose. This, however, did not have any beneficial result, but on the contrary, rather tended to destroy the granulation which had previously been (768—49) obtained. This is probably accounted for by the small quantity of ore used relative to the size of the cylinder so that during the whole of the rolling the granules were exposed to the air thus producing a considerable amount of float.

The charge was next put through the upcast and yielded

Concentrates	450	grammes
Tailings	504	"

The loss in total weight is due to a certain amount of mineral being left in the cylinder.

The original assay of the ore used for this test was as follows:

Zinc	15.93%
Lead	16.71%
Insolubles	48.35%

The Concentrates contained 6.6% of gangue, the balance being a mixture of Galena & Blende, which was not analysed.

The tailings assayed:

Zinc	1.09%
Lead	1.63%

Neglecting the amount of ore left in the cylinder the recovery in the concentrates equalled:

Zinc	96.3 %
Lead	94.85%

853 This and other experiments have led us to conclude that the rolling process in a separate cylinder might be omitted and that the whole process can be carried out in the Gabbett. A test was carried out on a similar class of ore with the object of determining the (769—50) correctness of this view.

Expt. 8. As nearly as possible the conditions of this experiment as to the value of the ore, strength of the oil solution, time, etc., were maintained as in the previous test. After treatment of the two

lots of 500 grammes in the Gabbett, the two products were mixed together and re-treated by rolling in the Gabbett, from which the mixture was passed direct through the upcast and the light sands taken off. The coarse product was then slightly acidulated and re-treated in the Gabbett for 7 minutes and again put through the upcast. This treatment resulted in three products which consisted of:

557	grammes	concentrates.
205	"	light sands from the first upcast.
200	"	tailings.

The original assay of the ore used in this test was as follows:

Zinc	15.86%
Lead	19.69%
Insolubles	39.9 %

The concentrates contained: 11.65% insolubles.
The light sands assayed:

Lead	4.29%
Zinc	1.88%

The tailings assayed:

Lead	2.24%
Zinc	0.91%

The final recovery therefore amounted to 96.4% of the Zinc,
854 and 92.06 of the Lead, or a mean recovery of 95.1% of the total metals present in the original ore. (770—51)

These encouraging results have decided us to erect a model plant on the Gabbett system which will be capable of handling probably 50 lbs. of ore per day. This plant is nearly complete, and will have its first trial during the course of this week, the results of which will be immediately reported to you.

Yours faithfully,

SULMAN & PICARD.

COMPLAINANTS' EXHIBIT SULMAN & PICARD REPORT, SEPTEMBER 24, 1903.

Sulman & Picard, 44, London Wall, E. C.
24th September 1903.

John Ballot, Esq., 607 Salisbury House, E. C.

DEAR SIR:

Re Cattermole Process.

We beg to append report on the progress of investigation of this process up-to-date. Since our last report a very great amount of work has been gone through, both independently by Mr. Cattermole and by ourselves, aided by our assistants Messrs. Pudsey &

Chapman. The work done may be summarized briefly by the letters we wrote you.

Firstly. On July 14th, '03, advising you that the Cattermole process was completed to our satisfaction so far as the granulation step was concerned. (771—52)

855 Secondly. Our letter to you of July 27th, '03, advised you to complete the patent for the second or breaking down step as although the trials were not complete considerable progress had been shown in this direction.

Thirdly. On August 11th, we advised you to complete the breaking down process patent, and expressed the opinion that this second step now showed the prospect of being a considerable commercial success.

The work done has been so voluminous including many interviews with patent agents and patent counsel (Messrs. Terrell K. C. & Gordon K. C.) that we need only briefly refer to the chief lines of investigation. We enclose you herewith a tabular view which we drew out for the aid of counsel, setting forth the chief reactions involved in the Cattermole Process.

Firstly we will summarize Mr. Cattermole's independent work. (Here follows description of a test.)

A considerable interval ensued, during which time a complete experimental plant was installed. This consisted of a series of 6 circular glass vessels, each fitted with a revolving cone agitator, the necessary, power being derived from a ½ H. P. electric motor. The series of agitation vessels were divided into two, one of four units, the other of two. With each of these sets an up-current separation device was placed in circuit for the purpose of the separation of the granules of mineral (772—53) from the depleted tailings. The plant also included a mechanical ore feed, and

856 a glass emulsion tank fitted with agitator, together with liquor reservoirs and return pumps. After a few weeks the whole plant was put in satisfactory running order, and the dimensions of all pipe circuits, rates of agitation, etc., etc., satisfactorily fixed. A series of tests upon Broken Hill ore then followed and demonstrations of the working plant were given to yourself and friends associated with you, namely, to Messrs. F. A. Govett, Mr. H. C. Hoover, Mr. W. W. Webster and also to patent counsel, Messrs. Terrell, K. C. & Messrs. Gordon K. C. The plant operates as follows: The vessels and separation circuit are filled throughout with water, which may be either acid or alkaline, according to the requirements of the ore to be treated; in the case of Broken Hill a circuit of .2% sulphuric acid was employed. The dry crushed ore is fed by the mechanical hopper into the first cone agitator, where it also receives the due continuous addition of emulsion from the emulsion tank above. After receiving its due rolling agitation herein it continuously passes into the second vessel where a like agitation is given, thence into the third vessel and into the 4th. By this time granulation is well established and the fine sands and slimes are sufficiently clean to enable them to be removed; this is done by their continuous passage through the first up-current sep-

arator. The fine slimes are rejected and after settling the liquor is returned to the ordinary liquor circuit; then the heavy sands, together with mineral granules, are continuously passed from the bottom of the separator into (773—54) the fifth and sixth
857 cone agitators, where, by a continuance of the rolling agitation the mineral granules are so increased in size (and therefore in specific gravity) as to enable them to be finally separated from the heavy sands by passage through the second up-current separator.

The concentrations of Broken Hill ore effected in the plant have been exceedingly satisfactory, both slimes and sands almost mineral free having been obtained, whilst concentrates continuously and automatically delivered from the exit tube have been of high grade. The plant has shown itself capable of continuous work and to have a capacity of about half a ton per 24 hours, although the vessels were of such small size, the glass agitators not exceeding the working depth of six to seven inches with a diameter of 4½ to 5 inches. If these dimensions be merely cubed there seems reason to estimate that such a larger plant would treat 50 tons of material per day.

(Here follow descriptions of numerous tests.)

We have here only briefly summarized granulation work done to date, although the actual experiments extended over a considerable period; details of many negative trials necessary to establish these conditions can be seen in our own and Mr. Cattermole's notes.

The results obtained, however, fully justify, we think, our advice to you to exercise your option with regard to the granulation portion of the Cattermole process.

858 (Here follow descriptions of numerous tests in breaking down or classification of concentrates.)

We are, dear Sir,

Yours faithfully,

SULMAN & PICARD. (774—55)

Gabbett Agitations.

(N. B. Normal revolutions of cone about 1,000 per minute.)
(Here follows a table of eleven granulation tests.)

COMPLAINANTS' EXHIBIT SULMAN & PICARD REPORT, NOVEMBER 19, 1903.

Sulman & Picard, 44 London Wall, London, E. C.

Nov. 19th, 1903.

Received 20-11-03.
Partially Ansd. 23-11-03.

John Ballot, Esq., Chairman Cattermole Ore Concentration Syndicate, Ltd., 607 Salisbury House, E. C.

DEAR SIR:

We beg to report to you upon work done since the date of restarting the experimental plant on October 8th.

(Here follow descriptions of detail improvements and repairs in plant.)

The "10 ton" plant (so-called, although until the first runs therein are made it is impossible to gauge, even approximately, its capacity per 24 hours), has been designed on lines shown by experience gained with the small plant to be the most desir-
859 able. 40 gallon earthenware pans with rounded bottoms are being specified (775—56) as mixers, the number and disposition being the same as in the small plant, but with the addition of another series of 3 for retreating the coarse sands if such should be found necessary.

The small duplicate of present plant on order from Messrs. Still & Co., for Mr. Courtney, is progressing somewhat slowly.

Nagyag Tests:

A series of small trial tests was made on fresh ore supplied by Messrs. Alex. Hill & Stewart to ascertain whether this ore was amenable to Cattermole process. Mr. Cattermole made several trials previously, but expressed doubt as to whether the ores would prove tractable to the process.

The main difficulty experienced was loss of acid by calcite and other carbonates—acid being neutralized before granulation effected. This was overcome by starting with 0.1% acid water making the addition of ore and emulsion, then adding another 0.1% acid after agitation for some little time. Good shotty granules were separated by hand-worked upcast, leaving very fairly clean sands. The granules retained their shape after drying.

The main difficulty of loss of acid due to calcite has still, however, to be faced and further work is required to ascertain whether neutral metallic salts, etc., can be used in place of acid. The soap circuit process (alkaline method) is inapplicable owing to the great destruction of soap by this particular ore. (776—57)

860 The evolution of carbonic acid is also another great drawback, as mineral is floated up thereby; after standing (till liberation of CO_2 is complete), gentle rolling brings down and granulates the mineral, rendering it recoverable in an upcast.

(Here follow descriptions of numerous granulation tests.)

Further trials are in progress.

We are, dear Sir,

Yours faithfully,

SULMAN & PICARD. (777—58)

COMPLAINANTS' EXHIBIT SULMAN & PICARD REPORT, MARCH 4, 1904.

44 London Wall, E. C., 4th March, 1904.

Sulman & Picard, 44 London Wall, E. C.

4th March, 1904.

Received 5-3-04.

John Ballot, Esq., Chairman of the Cattermole Ore Concentration Syndicate Ltd.

DEAR SIR: The work done since the date of our last report has been largely of a constructive nature, viz.: the erection, alternation, running and testing of the Cattermole oil (trial) plant for Mr. Courtney (The Sulphide Corporation Manager) at Cockle Creek.

This Plant has been built to your orders under our supervision and with Mr. Cattermole's assent upon inspection, by Messrs. F. M. Still & Co., and has been erected and run at their works at Charles St. Farringdon Road.

861 This plant is now in efficient working order, tests having been made on Broken Hill ore "straight" therein, and is now to be taken apart, carefully numbered and lettered, and packed for despatch to Australia. Photographs of the plant have been taken, and copies of these will be numbered and lettered similarly, to aid in the re-erection of the plant in Australia.

This report will therefore deal mainly with the modifications made in the Courtnay apparatus as found advisable after experience with the original type plant erected at 44 London Wall.

(1) The apparatus was similar in general design but (778—59) the ore feed was improved; this followed on a series of ore-feed experiments undertaken at 44 London Wall, the hopper being provided with a mechanical stirrer operated by a worm wheel on the top shafting.

(2) Mixers employed: These were in three tiers, four being on the top row, three in the second, and two in the third; the last being for retreatment of coarse sands.

(3) The upcasts were made larger in capacity and were fitted one to each mixer tier.

(4) The cones in the last two mixers were driven from a second or counter shaft.

The details of the above plant are seen in the two photographs by W. Schuth, which are at the moment under duplication by Messrs. Vicars & Coy. Photos duly numbered and marked will be dispatched with the plant to Mr. Courtney.

862 With Broken Hill ore the new ore mixer permitted an even and easily regulated feed.

The new emulsion feed gave a sufficient flow without it being necessary to resort to air pressure; apparatus for this was, however, supplied in case of necessity.

The speed of the main shop shafting was 250 per minute and the speed of the fast (normal) cones, about 988 per minute.

Owing to the increased size of the upcast, made in deference to Mr. Cattermole's suggestion as to the limited capacity of those based upon the first or smaller plant, it was found necessary to enlarge all the circuit supply pipes and to obtain a larger return pump.

In the retreatment mixers if the speed was fairly high the pulp did not flow out sufficiently fast unless (779—60) the baffles were so placed that one of the legs was placed just beside the outlet tube on the further side of the latter, in order to deflect pulp into the exit tube.

It was necessary to constantly regulate the emulsion feed, owing to the exceedingly variable temperatures of Messrs. Still's workshop in which the trial of the plant was carried out. This was due to the proximity of brazing furnaces and forge—intermittently used—to our apparatus. This lack of uniformity of conditions greatly militated against the obtaining of the best results and acted prejudicially against any long continued runs.

The general results have been, however, on the whole highly satisfactory, and some of the best products ever obtained by
863 the Cattermole process have been secured.

The original assay of Broken Hill ore used in these runs was as follows:

Lead....19.52%
Zinc.....16.69
Gold....traces
Silver...14 ozs. 11 dwts. 6 grains.

The sample was ground by Messrs. Johnson & Sons to 60 mesh.

(Here follow descriptions of two runs or tests of this apparatus with this ore.)

The general of this run was therefore very poor, the concentrates being poor and containing much gangue. The variation, however, of the emulsion was great being from 3 to 10 cc. per minute. Another cause was due to the induction of air with mineral into upcasts. The various bends on the outflow pipes were altered several times (780—61) until more satisfactory flows with a minimum of air inclusions were obtained; and it was decided that the granulation would be helped by the inclusion of more fine ore.

Run 3. (Independent of several small intermediate runs made to determine various factors in connection with the plant.)

Ore. 15% of fine ground Broken Hill ore was added to the main bulk of 60 mesh material, and a further bend put into outlet No. 2.

Emulsion. Used as before, but with the addition of 1% of oleic acid. The ore put through was 25 lbs., at the rate of 14.2 lbs.
864 per hour; the emulsion rate was 8 cc. at first, afterwards dropping to 6 cc. per minute. Total = 380 cc. = 3.8% of oil on mineral.

Run started as usual by putting 500 grammes into each mixer, granulating this, and then opening continuous flow. No stoppages occurred during this run.

Flotation factor used:

The tailings were retreated as before, but on this occasion the coarse sands when passing through the last two mixers were allowed to be beaten well with air, by keeping the liquors low in the mixers and using fast agitation with baffles in. The concentrates were then found to be floated up in the upcast if only a gentle up current were used; the test thus started with granulation as usual, but the retreatment was partially affected by flotation. This was necessitated by the fact that flotation did occur to some extent in the first process, giving dirty sands which could not be completely cleaned by re-granulating; the flotation cause of trouble was therefore used as its own remedy in the case of the last two retreatment mixer (781—62) series.

Granulated concentrates won	41.4%	
Containing	12.8%	insolubles.
Retreatment concentrates	12.2%	
Containing	12.2%	insolubles.
Flotation concentrates	2.6%	
Containing	31.2%	insolubles.
Total concentrates won	56.2%	
Average insolubles	16.3%	
Fine tailings	26.8%	

865 Assay:

Lead.....3.29% of which 1.31% oxidized.
Zinc 1.41
Coarse Tailings..17%

Assay:

Lead.....3.71 of which 0.48% oxidized.
Zinc .....2.71.

Note.—This oxidized lead present is probably as a protective covering over the other lead left behind.

Recoveries:

Zinc 94.3%
Lead.....92.2%

Run No. 4. (Mr. Keating present part of time.)

In this run the products were not retreated, but the last two mixers were kept low and the last upcast used for flotation separation. Ore (as in last run) put through = 24 lbs. at rate of 14 lbs. per hr. Emulsion (782—63) 33.3% R_2P_1 3.3% S. S., 0.5% oleic acid; rate = 3.8% of oil on mineral present.

Acidity of circuit before 0.23%
after 0.20%
Volume of circuit = 30 gallons = 300 lbs.
Loss of acid = 0.09 lbs. H_2SO_4 = 8.4 lbs. per ton of ore.

This, however, was not due to ore entirely, as the plain iron of the pump-plunger and one or two other iron connections were slowly attacked by the acid. This will, of course, be easily remedied in a large scale plant.

Concentrates (total) 54.6%
Insolubles 22.75%

866 Note.—Considerable trouble with emulsion feed during this run; but at one period a sample of concentrates taken before Mr. Keating and assayed showed only 10.5% insolubles.

Fine Sands....28.2%

Assay:

Lead.....4.64%
Zinc 1.54%

Coarse Sands..17.2%

Lead.....6.72
Zinc 6.12

Recovery:

Lead.....87.4%
Zinc 90.7

These results were therefore on straight products without any retreatment; and the bulk result would have been much better but for the serious fluctuations of temperature and therefore the difficulty of regulating emulsion flow. (783—64)

A portion of the coarse sands from the last test was retreated through the last two mixers with the addition of a little carbonate of lime.

The flotation concentrates obtained 1.6%, containing 14.2% insolubles and the coarse sands were reduced to

Zinc 3.44%
Lead.....4.16%

Using these figures the corrected recoveries become

Concentrates won = 56.2%
Lead Recovery = 87.8%
Zinc " = 93.9%

867 Other tests followed on modified lines which will be reported under a different head.

We are, dear Sir,
Yours truly,

SULMAN & PICARD.

COMPLAINANTS' EXHIBIT SULMAN & PICARD REPORT, APRIL 19, 1904.

Sulman & Picard, 44, London Wall, E. C.

19th April, 1904.

Received 20–4–04
Copy sent Mr. C. F. Courtney and Mr. Chapman.
April 22, 1904.

John Ballot, Esq., Chairman Minerals Separation, Ltd., 607 Salisbury House, E. C.

DEAR SIR: We beg to hand you herewith record of work done since the date of our last report.

The following samples of oleic acid were obtained (784—65) from Messrs. Charles Lamb & Co., of 60 Mark Lane, E. C., and analysed with the under-mentioned results:

Oleic Acid (tin)	56.6%	acid
Oleic Acid (bottle)	101.0	"
Distilled do	96.6	"
Saponification do	89.5	"
Red Oil	38.9	"

A further sample obtained 14/3/04 = 101.1% acid.
The latter was that selected.

The reason for two samples of the above showing over 100%
868 of oleic acid is due to the presence of fatty acids of lower molecular wt. than that of pure oleic acid, which, when expressed as the latter, give a somewhat higher reading—just as Sodium cyanide expressed in terms of Potassium cyanide should show 132% of KCy.

A series of tests were made to demonstrate the recovery of oleic acid. Ore, water and oleic acid were shaken together in the ordinary proportions, the weight of oleic acid used being carefully noted.

The top liquor was poured off from the granulated mass and found to contain no oleic acid, all having been carried down by the mineral. The latter was now treated by shaking with warm 2% caustic soda solution, the resulting soap liquor drained off, and the residue also washed with a little distilled water, the washings being added to the main liquor bulk; the mineral, etc., was left perfectly free from even traces of oil (oleic acid). The soap liquor was now neutralized with Sulphuric Acid, the oleic acid being turned out and floating to the surface. This was collected and quantified by titration with caustic soda standard solution 99.1% of the quantity of oleic acid originally taken being shown to be recovered. (785—66)

This operation was repeated twice on the same quantity of oleic acid with precisely similar results, showing that the recovery of this oil from mineral is practically speaking perfect.

The vanning experiments referred to in our last report were now continued. We endeavored to obtain the loan of the small 8′

Wilfley vanner (now dismantled) formerly in use at th
869 premises of Wilfley Co. in Old Jewry, but without succes
We therefore instructed our carpenter to make a small mode
3′x2′ table, which was done according to our designs.

A series of demonstrations were made on this table using "dirt
sands" obtained both from old material derived from Mr. Courtney'
plant at Charles St. and from ore freshly granulated in the repaire
Cattermole plant in our laboratory. Acid circuits from 0.2% to 0.5%
H_2SO_4 were used, the necessary carbonate of lime (in the form o
whiting) being mixed with the sands just as they were placed on
the table. The great bulk of the mineral was removed in large blac
flocks and floated over the riffles into the slime launder where it wa
collected; the sands and a very small quantity of residual mineral
worked off in the ordinary manner at the further end of the vanner.
The separations, though exceedingly good, were not perfect for th
following reasons:

(1) the table—and especially the riffles—were not long enough in
the very small model employed.

(2) the carbonate was too finely divided, giving off almost all it
gas at first contact with the acid water and leaving none to be gener
ated further along the travel. (786—67)

(3) The riffles were rather too high to allow the only feebly floate
mineral to be carried over.

The results, however, gave cleaner sands than we have ever obtaine
by other means and justified the trying of the experiment on a
larger scale.

This was done at the works of the Wilfley Co. at Lever St., City
Road, upon freshly prepared "dirty sands" in the presence
870 of Messrs. Ballot, Webster, Gregory and ourselves. Owing to
the shortness of the time at our disposal no proper arrange-
ments could be made for a flow of acid circuit liquor on the 16′ table
used; nor was any continuous ore feed possible. The material was
therefore fed on by hand and dilute (1%) acid sprinkled on the
ore (mixed with ½% of whiting) just as it began its travel. Under
these conditions a continuous test was impossible, but the results in-
termittently obtained were quite sufficient to demonstrate that the
principle of flotation vanning was the correct solution of the difficulty
hitherto experienced in cleaning up dirty sands.

The following are assay results on some of the products obtained.

(1) Test made on the small model table, dirty sands being fed
on continuously from No. 2 up-cast; 0.4% H_2SO_4 being the acidity
of the circuit, and ½% whiting being added, as a pulp, to the issuing
sand.

Concentrates	20.75%	Insolubles
Tailings	2.4 %	Lead
	2.9 %	Zinc.

The difficulty here was, in absence of proper appliances (time
being too short to install these) the due admixture of carbonate and
sands. Still, however, the results (787—68) are very fairly good,

bearing in mind the fact that the sands were purposely very heavily loaded with mineral.

871 (2) Wilfley Test at Lever St.

(*a*) Large test:

Concentrates 34.1% Insolubles
Tailings 4.8% Lead
3.95 Zinc

In this test the difficulty experienced was in obtaining the uniform feed of acid; as before pointed out, this was added by hand intermittently, and could only be applied at one part of the table. At the moments when the conditions were right the sands came off in absolutely clean lines, but when the deficit of acid occurred much mineral escaped into the tailings.

(*b*) A smaller test on the same table gave:

Concentrates. Insolubles 25.75%.
Tailings Lead [illegible]%.
Zinc 0.75%.

In a properly arranged vanning plant the latter results could be made absolutely continuous in our opinion.

(We refer to the remarks made in the Working Instructions prepared by us, and forwarded to Mr. Courtney with regard to "shaking tables." We think these would answer even better than vanners of the Wilfley or Buss types. This can be tried by removing the riffles from your small model table and altering the motion from a longitudinal rocking motion to a sharp jerk or knock. The circuit water will be fed on as usual, but the table will be only very slightly inclined towards the slime launder and less circuit water will be required.)

872 After the conclusion of these tests and after the Easter recess, the plant at our laboratory began to be dismantled (788—69) for removal to Aldermanbury Avenue. We were also engaged for many days in preparing the full working instructions for Mr. Courtney above referred to, a copy of which we have supplied to you.

Mr. Chapman left on Friday last, the 15th inst., for Australia, fuly instructed by us and yourselves.

During the period of the re-installing of the plant we are carrying out a series of trials as to the recovery of Hydro-carbon oil (emulsion) from the concentrates.

The concentrates contain as a rule from 3 to 5% of oil—say averaging 4 %. When these are dried up from adhering water the oil is hardly apparent or visible, and they are almost crisp and granular to the touch.

From 3% oiled residues nothing is extractable by pressure and the means adopted for recovery of the oil must be moderate in cost. 3% of oil on the concentrates is equivalent to say 1½% on the original ore: 1½% of oil = 33 lbs. per ton of ore. 4% of oil similarly = 44 lbs. per ton of original ore or almost 4½ gallons. Taking

the cost of oil at £6 per ton in Australia, 44 lbs.=2/4d. per ton
ore, if none is recovered. There is therefore only a small margi
available for recovery costs. Further the petroleum ersidues (
found by Mr. Cattermole) are exceedingly difficult to remove wit
any degree of completeness from galena; in this respect they diffe
materially from paraffin oil, and as you will recall gave great diff
culty in the breaking down process. We have tried ver
873 many experiments with soap solution, and soda caustic do
separately and mixed, from 1 to 10% in strength, but i
every case 1 to 1½% of oil has been left behind. Each (789—70)
1% of oil represents 7d. per ton on the original ore.

We have tried the effect of heat with these re-emulsifying agent
on oiled concentrates and find this advantageous. Steaming in
press might give good results, but we have no available apparatu
to determine this.

We are trying the effect of emulsifying solutions under pressur
and temperature and will report same to you shortly.

Yours faithfully,
(Sgd.) SULMAN & PICARD.

P. S.—We beg to return Kendall's specification herewith
There is of course nothing that interferes with your patents therein

We also draw your attention to Van Meter's Aluminated Hydr
carbon oil process, which is being advertised somewhat largely i
South America. It is a flotation process of the Elmore type, bu
with specialized apparatus. Van Meter's process is equally foreig
to the patents held by you and we only mention it as putting ou
knowledge of the process on record with you. The better know
oil processes (so far tried commercially) are

Robson's; paraffin oil pumped through an ore pulp; now obsolete
Elmore; flotation by means of viscous hydro-carbon oils; also oile
belts and table appartus.
874 Scammel; flotation by means of hydrocarbon oils thickened
etc., by means of Sulphur di-Chloride.
Kendall; flotation of graphite only, by paraffine.
Van Meter; flotation by means of thick hydrocarbons rendered
more viscous by the employment of acid salt of alumina.
Owns the Everson patent.

SULMAN & PICARD. (790—71)

COMPLAINANTS' EXHIBIT SULMAN & PICARD REPORT, MAY 2, 1904.

Sulman & Picard, 44 London Wall, E. C.

May 2nd, 1904.

Received 4-5-04.
Board 18-5-04.

John Ballot, Esq., Chairman Minerals Separation, Ltd., 607, Salisbury House, E. C.

DEAR SIR: We beg to report on a trial experiment on the Cattermole process of granulation to determine the effect of temperature.

In the "Van Meter" process (pamphlet) it is stated that, with the particular oil used therein,—viz., heavy hydrocarbons thickened with said Alumina salts,— at a temperature of 140° F., Zinc blende is not taken up. In order to ascertain whether this alleged fact would aid in the classification of Broken Hill ore by preventing the inclusion of the blende in the granules, a series of shaking tests was made at temperatures ranging between 50° and 90° C.

875 At the lower of these no marked difference was apparent, but when the temperature approached 80° C., it was evident that some mineral was escaping granulation. This from its color appeared to contain more blende than before, and after two or three further trials the best apparent separation was passed through a small upcast apparatus.

The fines which floated off and the coarse material which fell were assayed with the following results:

Coarse:
Zinc.....13.41%
Lead.....11.58%

Fines:
Zinc.....19.87%
Lead.....22.58% (791—72)

No separation was therefore effected; indeed the finely divided galena had resisted granulation even more than the blende, although not indicated by colour.

Nevertheless the effect of increased temperatures in preventing granulation of fine mineral was so pronounced as to perhaps make it worth while to investigate the subject further.

Though inapplicable to the separation of Broken Hill ore minerals, we think you would do well to take note of heat effects generally, and at some future time to determine the various temperatures at which the more commonly occurring minerals, at a given mesh, refuse to take up oil from the same emulsion.

We are now carrying out a series of concentration tests on Nag-

yag ore, on the lines indicated in our conversation with you
876 this afternoon.

We are, dear sir,
Yours faithfully,

SULMAN & PICARD.

COMPLAINANTS' EXHIBIT SULMAN & PICARD REPORT, MAY 18, 1904.

Sulman & Picard, 44, London Wall, E. C.

18th May, 1904.

Received 18-5-04.
Answered 24-5-04.
Board 18-5-04. J.B.

Messrs. The Minerals Separation, Ltd., 607 Salisbury House, E. C.

DEAR SIRS: In answer to yours of the 16th inst., asking for a detailed report of work up to date, we are unable to give you, by this meeting, full details of the work done, as (792—73) much of it is still in hand and will be more suitably dealt with in the course of a few days, certainly by the end of the month.

Kindly, therefore, regard the present as a short interim statement.

Plant at Aldermanbury. This is in efficient working order and several runs have been made along the older lines, but with certain small modifications.

First. A different emulsion has been used, following on suggestions from Mr. Cattermole, namely, R_1P, plus 20% of oleic acid. This results in giving cleaner sands, and the oil is somewhat more readily recoverable from the concentrates. We have experimentally used such mixtures ourselves, but one objection to it was
877 the difficulty we found on a small scale of recovering the oil in suitable emulsion form. Doubtless this difficulty could be overcome, and we are undertaking a series of experiments with the same, in accordance with your wish.

Hitherto, therefore, we have preferred to use either Hydrocarbon oils with an absolute minimum of Oleic acid, or else Fatty acids free from Hydrocarbon admixtures.

Secondly. The other modification has been the driving of the 6th mixing vessel at lower speed. which is certainly a step in the right direction, so far as Broken Hill ores are concerned.

Clean up of Dirty Sands.

This work gives considerable promise of early success. As foreshadowed in our last, we have converted the small model vanning table into a "bumping" table, and have removed the riffles. By this means on small samples of (793—74) dirty sands we have been able to clean up nearly all the contained oiled mineral, and to pro-

duce sharp clean sands without the use of any gas producing carbonate, etc., thus effecting considerable economy both in acid and carbonate. Under these conditions mere contact of the oiled particles with air when exposed on the surface of the table is sufficient to ensure their flotation removal from the sands.

The representatives of Messrs. Anthony Gibbs witnessed an exhibition run on the lines referred to in the three preceding paragraphs, and expressed themselves as pleased with the separations obtained.

878 Mr. Chapman.

We see the arrival of the S. S. "Oratava" at Adelaide was cabled on Monday last; Mr. Chapman is therefore (presumably) by now on the Central Broken Hill mine.

Nagyag Ore.

Having obtained the consent of Mr. H. A. Whitaker to experiment on samples of this ore, which he had stored with us, we undertook a series of trials. These are at present incomplete, and we should like your instructions to continue them. We have dealt with the ore on the lines of preliminary water, concentration, separating coarse crushed material from the slimes and submitting the separated course to vanning, by means of a plaque. A very fairly sharp concentration of the course material into sharp mineral and clean sands was thus obtained, assays of which have been made and will be given in the complete summary of these tests. The slimes which contained high (794—75) values in gold and silver, were submitted to oil concentration both by flotation and granulation. The first trials do not show a complete extraction of these slimes, but gave indications that a very close recovery is possible.

In dealing with material of this nature we find that much depends upon the thickness of the slime pulps treated; if the pulps are too thick, which was the case in our first trials it is difficult to bring all the oiled mineral out, either by granulation or flotation, but by treating a more dilute pulp this objection is overcome. We have made many assays of the intermediate products obtained,
879 which we propose to give in our complete report.

We take this opportunity of expressing our conviction that with the exception of Broken Hill ore, and occasional ores of this type, (that is, where the gangue and mineral are much of the same specific gravity) the legitimate sphere of any oil concentration process will more and more in future be confined to the treatment of slimes. In other words preliminary water concentration must be used to the fullest extent to which it is available, and only such products as escape the action of water concentration should be submitted to the action of oil. There are many reasons for this which will at once be apparent to you: foremost amongst which are (1) the contamination of coarse material, either mineral or sands with oil, for which there is no need; secondly, the inutility of putting coarse material through plant demanding special attention, and thus

diminishing the legitimate capacity of such plant, when such material can be dealt with in a simple and economical water plant. (795—76)

The credit of making water concentration, thus, to a large extent applicable to ores which cannot be reduced by this means alone, will still belong to the oil process, whilst the economies are apparent.

We are dealing with Nagyag ores on these lines; and you do well to devote therefore, considerable attention in the near future to the treatment of pure slimes.

Yours truly,

SULMAN & PICARD.

880 COMPLAINANTS' EXHIBIT SULMAN & PICARD REPORT, FEBRUARY 17, 1905.

Received 18–2–05.
Board 22–2–05.
J. B.

Sulman & Picard, 44 London Wall, E. C.

17th February, 1905.

Messrs. Minerals Separation, Ltd., 62 London Wall, E. C.

DEAR SIRS: We are in receipt of your letter of to-day with regard to Schwarz's patent No. 23906 of 1904, and have considered the documents sent in connection therewith by Messrs. Boult, Wade & Kilburn. We think you are quite safe, and that if desirable, any part of this patent which may be considered to infringe your rights can be stopped by reference to the existing patents which you have. We think, however, it is desirable that we should all see Messrs. Boult, Wade & Kilburn's representative, Mr. Ballantyne, on this point and would therefore ask you to fix an appointment at your convenience.

We have lately been struck with the fact which is already known to your staff at Aldermanbury and elsewhere, (796—77) namely, the enormous aid to the oiling and granulation of minerals which is afforded by the increasing of temperature of the circuit. An ore that would barely granulate at a temperature of 12° C, with 3% Oleic acid will readily oil and granulate in about three or four minutes if the circuit be warmed to say blood heat. This can simply be effected by the use of a closed steam pipe or coil
881 placed conveniently in one or more places in the circuit, or in the granulating vessel, and the slightly increased heating desirable can thus be very economically obtained. Not only is the operation more perfect with heat, but the capacity of the plant is enormously increased and we are inclined to contribute at least a portion of the excellent results obtained in the large tests in Australia to the higher temperatures prevailing there, compared with London. This point seems of such imporatnce that you would do well to enquire of Messrs. Boult, Wade & Kilburn whether this is not worth protecting by patent; in any case we think you would

do well to have a series of tests made to quantify the heat effect more accurately.

With regard to the clean up of dirty sands by other means than a table (more or less of the Wilfley type) fitted with air pressure jets. We have made a series of trials and small apparatus designed more or less on the principle of the hand plaque, which gives such excellent results upon the small scale. The first of these consists of a strip of linoleum about 3 ft. long and about 6 ins. wide; this was slightly dished into a very flat concave through throughout its entire length, and placed at a slight angle, the lower part of the linoleum trough dipping (797—78) into the water. A suitable water spray or fine jets were placed over the trough to give a downward wash, and a slot, sufficient to permit the intercepting of any sands passing down into it, was cut across the width of the trough just below its entry into the water. Under this slot a separate vessel
882 immersed in the water was placed to catch the sands. The whole trough was capable of being given a slow rocking or tilting or jerking motion from side to side.

A portion of the dirty sands containing oiled mineral values was placed at the top of the inclined linoleum trough, and a gentle reciprocal rocking or jerking motion from side to side was given to it; the sands were rapidly cleaned, and washed down the centre of the trough continuously, as they were swayed from side to side, whilst the mineral was rapidly floated off into the current of the water running down the centre of the trough, and was thus carried over the slot into the water beyond this where it could be collected; the sands on the contrary were intercepted by the slot and collected separately. This apparatus gave remarkably good results, the sands separated being absolutely clean, but the difficulty was that the mineral "float" on reaching the water surface at the bottom had a tendency to be sunk again, just by the slot, and to be thus mixed again to some extent with the clean sands. With a little experiment this type of apparatus could no doubt be readily improved, and this difficulty overcome. The second type of this apparatus consisted in putting a second linoleum trough of rather greater width exactly under the first, and increasing the side rock of the apparatus to such an extent that the floating mineral (798—79) was alternately carried over the opposite sides of the top trough and thus fell into the bottom, collecting trough, which was provided with a suitable receptacle to collect this; whilst the sands were sufficiently
883 heavy not to be carried over the side of the top-trough but continued their downward travel to their own receptacle at the bottom of this. With one or two modifications this type of apparatus gives promise of excellent results; but we were unable by hand-rocking to get the motion so exactly uniform as to carry off all the floating mineral over the side of the launder without permitting the escape of any of the sands at the same time. No doubt with simple mechanical rocking apparatus this type of apparatus would answer well. A further type again of this consisted in having a perfectly flat upper strip of linoleum, protected on each side by a fillet of wood about ¼ inch in depth, thus forming an extremely shallow trough.

Strips of wood ½ inch in depth and about 4/7ths of the width of the linoleum were tacked on to the latter from alternate sides with a slight downward angle. These fillets of wood acted as baffles, retarding the too rapid downward travel of the sands as the shallow trough was tilted from side to side. The ¼ inch fillet along each side of the linoleum was sufficiently deep to prevent the sand from being carried over it, but permitted the floating mineral readily to escape into the similarly inclined trough placed below it.

A fourth type of apparatus has also given excellent results. It consists in what may be termed a modified type of the Frue vanner. An endless india-rubber belt about two feet in length (with filleted sides to prevent the escape of material over these) was made to travel between (799—80) its two stretching rollers at a slightly upward inclination. The belt was also capable of being given an
884 alternating side shake or a similar rocking motion.

The dirty sands were fed in to the belt at a point about ¼ of its length above the bottom roller. Suitably disposed sprays or jets of water were placed at various distances above this sufficient to give a very slight and gentle downward current of water over the belt. In this way the mineral was floated and washed continually downwards into a receptacle placed beneath the bottom roller whilst the sands were constantly removed upwards by the motion of the belt and were taken off quite clean at the top of the belt as this passed over the top roller. A very slight inclination of the belt is necessary in order to prevent the fine sands from being washed downward with the slight water current.

These few details will be sufficient for anybody with mechanical knowledge and facilities to design one or more working apparatuses which will have a large capacity of output and will be simpler in construction perhaps, than the air blowing table which is at present the only apparatus in use for your purpose.

We are, dear Sirs,

Yours truly,

SULMAN & PICARD.

(800—81)

885 COMPLAINANTS' EXHIBIT SULMAN & PICARD REPORT, FEBRUARY 21, 1905.

Sulman & Picard, 44 London Wall, E. C.

Received 21/2/05.
Board 22/2/05.
J. B.

21st February, 1905.

John Ballot, Esq., Minerals Separation, Ltd., 62 London Wall, E. C.

DEAR SIR: We beg to report the results of analysis of sample of "fine" dirty sands from Aldermanbury Avenue, which were obtained from the Oleic acid run a short time ago.

The sample contained 11.84% lead, and 13.39% zinc; Oleic acid

0.51% iron present as Oleate (and therefore soluble in Ether)= 0.037% equivalent to 0.408% of iron soap, which is again equivalent to about 0.36% of combined Oleic acid. This analysis is instructive, showing that the dirty sands contained over one-third of their Oleic acid as iron soap. This is a curdy, sticky, substance, and doubtless it sweeps together into flocky masses, oiled mineral, and oil, together with gangue. We have noticed previously that, in the insoluble form, soaps do certainly tend to adhere to gangue. It is worthy of note that no lime soaps were found in the above sample.

It is rather too early to definitely sum up the full advantages or disadvantages of iron soaps, but these bodies appear to us to give rise to the following difficulties.

886 (1) They tend to grease gangue as well as mineral.

(2) They are highly contractile and curdy bodies: i. e., when produced in dilute solutions they tend to shrink together into small curds or clots which may thus contain gangue, mineral, air bubbles, (801—82) oil globules, etc., etc. It is highly probable that at least some of the loose flocks noticed may have a basis of iron soap.

(3) Loss of Oleic acid in the fine sands which contain iron soaps. It will be necessary for us to see whether iron soaps once formed can be broken up by treatment with dilute acid or alkali, for the recovery of their contained fatty acid. It would also be interesting to see whether the oiled concentrates also contained insoluble iron soaps. We had a consultation yesterday with Messrs. Leechman & Higgins, and pending the institution of the instruction book have decided upon the following programme for immediate purposes.

(1) Mr. Leechman will make two tests with alkali and water on straight Broken Hill ore, using triangular separating pieces of wood fixed upon the end of the Wilfley table in order to get the sharpest separation of vanned products. We propose only to use only the smallest quantity of ore that is capable of giving a definite result on the Wilfley table in each case; say 15 to 20 lbs.

We also propose to repeat these trials two or three times in order to ascertain whether the separations can be judged sufficiently closely to ensure consistent results, and thus to afford reliable indica-

887 tions as to the value of alkali versus ordinary water in vanning.

(2) Mr. Higgins will carry out a series of a (802—83) few small Gabbett runs in order to determine the best combined time and temperature factor for Broken Hill ore used with straight Oleic acid.

We will select with him the most generally suitable factor resulting from the foregoing, and this will then be applied in the large plant in two runs, (*a*) run on 40 lbs. with the plant as arranged at present (*b*) run on a similar amount but with a fresh fine sand's upcast used only after the last of the series of Gabbetts. From the information thus derived we ought then to be able to make a standard run, on 1-cwt. or 2 of ore.

We may recall that since the last run of this kind proved unsatisfactory, the following improvements or alterations in the general

process have resulted: (1) The discarding of emulsions of Oleic acid, and the use of the acid direct, thus permitting a uniform and easily regulated oil addition. (2) The locating of iron soaps, and the presence of considerable quantities of this in the dirty fine sands. (3) The method of protecting metal surfaces which we have worked out (and are still working at) in order to prevent the destruction of the apparatus and the formation of insoluble metallic soaps whilst (4) the question of temperature forces itself upon us as likely to have a controlling influence on the question of output.

(5) The proposal to use only 1 upcast at the end of the complete series of Gabbett's which will permit of a much longer cleanup
888 period for the fine sands. These sands were very dirty in the last long run and all oil and metal values contained by them is entirely lost at present. In a series of over a dozen experimental runs which we have lately made in our laboratory we have proved (803—84) that with small amounts of Oleic acid the fine sands and slimes can be absolutely cleaned from mineral, provided sufficient agitation be allowed. This fact, therefore, strongly supported the modification of the apparatus as proposed, namely, one upcast only (for the separation of the fine sands), and the employment of this only after the full agitation period of which the plant is capable.

We are therefore much better prepared for our next run than was the case when the previous attempt at a standard run showed the necessity for the foregoing improvements.

* * * * * * *

We are, dear Sirs,
Yours truly,

SULMAN & PICARD.

COMPLAINANTS' EXHIBIT HIGGINS REPORT, MARCH 2, 1905.

Copies sent C. F. Courtney & Geo. A. Chapman 3/3/05.
Received 3/3/05.

Report on the Conditions of Granulation.

March 2nd '05. Preceding work having proved that the
889 temperature at which granulation is effected has a great influence on the duration of agitation required, instructions were received from Mr. Sulman to determine the rate of change of granulation with temperature. During these experiments the influence of other conditions was sufficiently marked to suggest to me their importance in altering the time of (804—85) granulation, and these conditions have been carefully examined.

The Influence of Acidity.—Our experiments here confirm those of Mr. Chapman in Australia, viz., that an increase of acid in the circuit causes a decrease in the time required for granulation. There is only one slight objection, which becomes noticeable when the solution is heated, viz., a slight evolution of sulphuretted hydrogen due to the solution of the sulphides. The iron pyrites may be the de-

linquent, which would account for the large percentage of iron in the circuit, reported a short time ago.

It will be seen from the curves that the influence of acid is much greater at lower temperatures than at higher.

Influence of Heat.—An increase in the temperature of the solution causes a decrease in the time of granulation. This is very marked, from a temperature of 8 or 10° C. to about 40° C. when an increase of temperature does not cause a very great decrease of time. The effect is startling when the former are compared with the latter.

(Here follows descriptions of 9 tests in 6 mixer plant and 18 tests in single Gabbett at temperatures from 17° Centigrade to
890 57.5° Centigrade, using oleic acid in proportion of 1.5% on ore.)

The oleic acid which we are using begins to solidify at 12° C. and continues so doing until 0° C. is reached when it is almost solid. Obviously a solid oil is not capable of oiling a surface. Thus granulation cannot be expected when the temperature of the solution falls below the solidifying point and this fact may explain the great (805—86) length of time required at low temperature.

Influence of the Thickness of the Pulp.—Starting with a thick pulp, i. e. 1 of ore to 1 of water, the time of granulation is long and decreases as the proportion of water to ore increases, but, between 2 and 3 of water to 1 of ore the rate of change makes a great alteration and after the latter proportion becomes nearly constant at all proportions of water.

Experiments.—Acid Tap water, ore, oleic acid, &c., as in last series.

(Here follow descriptions of 6 tests at different ratios of ore to water.)

Influence of Peripheral Velocity of Cone.—An increase in the peripheral velocity of the cone causes a decrease in the time required for granulation, a point being reached after which this decrease is slight. Further experiments are to be carried out on this subject to determine the influence of friction of the sides of the Gabbett on the peripheral velocity of the cone. The speeds should also be taken still lower.

(Here follow descriptions of ten tests at from 840 to 1462 revolutions per minute.)

Acidity 1%, ore 500 gms., water 1500 gms., oleic acid
891 1.5% on ore. Results plotted in red on sheet II.

There is one thing to be noted in all these experiments, viz., that the point at which granulation is complete is arbitrary and has to be judged by the appearance of the Gabbett contents, this can be done by practice but it not exactly a perfect method. (806—87)

Experiments are also to be carried out on the influence of the quantity of oil present in order to complete the information regarding granulation.

Instructions have been received from Mr. Sulman regarding the influence of the size of the mineral.

A. HOWARD HIGGINS.

COMPLAINANTS' EXHIBIT SULMAN & PICARD REPORT, MARCH 3, 1905.

Sulman & Picard,
44 London Wall, E. C.

Copies sent C. F. Courtney
& Geo. A. Chapman 3-3-05.
Received 3-3-05.
Board 19-4-05.
J. B.

3rd March, 1905.

John Ballot, Esq., Minerals Separation, Ltd., 62 London Wall, E. C.

DEAR SIR: I beg to acknowledge receipt of copy of Mr. Higgins' report from you this day together with curve diagrams, both of which are returned herewith.

892 I am in full agreement with Mr. Higgins' report, only a few remarks being called for.

Page 1. Influence of Acidity.—We do not think that the iron pyrites is responsible for the production of sulphuretted hydrogen on being heated with 1% acid, so much as is the ferruginous blende. (807—88) The formation of H_2S bubbles in this way, is, of course, the basis of the Potter and Delprat processes for separation of blende, and experience has shown us that ferruginous blende is more readily attacked by hot dilute acid than is pure blende. The large percentage of iron in the circuit liquors noticed of late is more probably due to the action of an acid upon cast iron surfaces exposed to the acid circuit.

Page 2. The curves showing the effect of ferrous sulphate as aiding granulation in warm solutions, but retarding the same in cool solutions (as compared with circuit liquor free from ferrous salts) is most instructive, and should be examined more closely hereafter; the effect of calcium soaps also requires investigation. In writing to Mr. Chapman we would be glad if you would forward to him paragraphs in our recent reports bearing upon the question of iron soaps. Whilst they may aid in granulation we do not think that such aid may be of unmixed benefit. Whilst we are not certain of the point, it appears to be likely that these iron and other metallic soaps are responsible for a considerable proportion of the "flocks" noticed, and therefore for the production of dirty fine sands, as see our last report.

We are in full agreement with the rest of Mr. Higgins' observations, and may summarize the work now being done at Alder-

893 manbury Avenue as the determination of the following factors.

(1) Influence of acidity on granulation,
(2) " of temperature on granulation,
(3) " of speed of Gabbett agitation on granulation (808—89)
(4) Influence of ratio of ore to liquor on granulation,
(5) " of metallic salts on granulation,
(6) " of the size of particles and of the influence of slimes on granulation,
(7) " of the amount of oil on granulation.

The above factors are being determined on
(*a*) Oleic acid,
(*b*) Residuum oils.

Mr. Higgins' present report is therefore the first instalment of the above scheme of trials. The influence of the speed and type of agitation becomes a factor of great importance according to our recent experiments. Speeds of rotation (with a small Gabbett) varying from 3 to 500 revolutions per minute proved almost useless. We then made a series of baffles which were placed in the Gabbett and which were "solid," i. e., they occupied the greater free space of the Gabbett vessel from the glass sides up nearly to the working surface of the cone. They were found to be disadvantageous as they gave too violent agitation, and set up large eddy currents in front of each baffle, greatly reducing rotation speed of the liquor in the Gabbett and adding water friction to such an extent to the rotating cone, that the power required to 894 drive the latter was more than doubled. On replacing these solid baffles by the ordinary type of thin rod baffles, the granulation period was much improved, and the power consumed in driving the cone fell again to the normal. The number of revolutions made by the rotating cone shaft mean nothing apart from the average diameter of the cone. Hence, all cone revolutions should be reduced to peripheral (809—90) cone speeds, expressed in velocity in feet per minute, as has been done by Mr. Higgins. The importance of this will be manifest to Mr. Chapman in putting up the larger cones at Broken Hill.

We have also carried out a series of experiments with a small centrifugal pump in place of a Gabbett, to determine whether this gives a better form of agitation than the cone. Fearing the cutting effect of sharp sands on the blades of the centrifugal pump, Broken Hill ore which had been passed through a 120 mesh sieve was used.

The following figures were obtained by Mr. Leechman yesterday in comparison with the Gabbett, and show the latter to be distinctly preferable to the centrifugal pump, so far. In fact the figures are so conclusive that for the present we do not intend to continue centrifugal pump experiments. We may mention the centrifugal pump used was only a small one having about a 4½ to 5" chamber but it was speeded up to about 1,200 revolutions per min. The pump therefore had a considerably higher peripheral speed than the Gabbett used in parallel tests.

895 (Here follow descriptions and tables of numerous tests.)

We are, dear Sir,
Yours truly,

SULMAN & PICARD. (810—91)

COMPLAINANTS' EXHIBIT HIGGINS REPORT, MARCH 16, 1905.

Copies sent to C. F. C. & J. A. C.
17/3/05.
Copy sent S. & P. 6/4/05.
Received 17-3-05.

Further Report on the Conditions of Granulation, March 16th, '05.
Influence of the Percentage of Oil.

The effect of diminishing the percentage of oleic acid is to alter the type of oiling; the higher percentages producing granules, and the lower ones froth. 6% of oleic acid on the mineral is sufficient to form good granules without much froth. This froth consists of insufficiently oiled mineral mixed with large quantities of air. As this percentage of oleic acid is decreased, the time for clean up of the sands is increased and more froth is formed. 0.62% oleic acid on the mineral is insufficient to form any granules and nearly the whole of the mineral comes to the surface, on stopping the cone, as froth. 0.2% acts in the same manner leaving the coarse sands with rather more mineral in them. (This is 0.1% on Broken Hill Ore.) In all cases the oil has been measured in cubic centimeters and the percentage calculated as though they weighed grams but as
896 the specific gravity of the oleic acid is less than unity this is not the case and, all percentages will be lower than those actually given. (811—92)

Details of Experiments.

Acid.	Oleic acid.	% of oleic.	Time.	Temp.	Remarks.
1.1%	15 cc.	3% on ore	4 min.	30.5° C.	Very little float.
"	7½ cc.	1.5% " "	4¼ "	31 "	Rather more float.
"	5.2 cc.	1.04% " "	6 "	31 "	Still more float.
"	3.1 cc.	0.62% " "	6 "	32 "	
"	1.6 cc.	0.32% " "	7 "	31 "	Float vastly increased.
"	0.5 cc.	0.10% " "	8 "	31 "	Float vastly increased.
"	0.5 cc.	0.1% " "	4¾ "	29° "	Not finished.
"	0.4 cc.	0.8% " "	6½ "	30.5° "	
"	0.5 cc.	0.1% " "	8 "	31° "	
"	0.5 cc.	0.1% " "	8 "	31° "	Weight of concs. 170 gms.
"	0.2 cc.	0.4% " "	8 "	32° "	Apparently not much different.
"	0.1 cc.	0.002% " "	12 "	32° "	Little worse.
"	none	none	7 "	32° "	Very little float.
"	none	none	10 "	32° "	More froth.

The froth in the last case was found to be due to some concentrates sticking inside the Gabbet cone from previous experiments.

Oil.	Time.	Acid.	Temp.	Wt. of float.	Remarks.
none	(8) m. (16) "	1.1%	32°C.	——	No froth only slime.
none	16 "	1.1%	32°C.	——	ditto.
1.2 cc.	5½ "	1.1%	31°C.	——	Some galena unoiled.
none	10 "	0.877%	31.5°C.	1.102 gms.	For assay.
.5 cc. oleic.	12 "	"	31°C.	203 gms.	——
.5 cc. Balkhany	12 "	"	32°C.	——	Very little float.
1 cc. ditto.	12 "	"	32°C.	——	ditto.
2 cc. "	10 "	"	32°C.	——	Very little float, small granules.
5 cc. " (812—93)	5 "	"	46°C.	——	Less float.
.5 cc. para-fine increased to 1% in stage	15 " 18 "	"	40°C.	——	Very little float. Sands not quite cleaned with the increase of oil.
	(distilled water)				
.5 cc. oleic.	10 "	.877%	32°C.	——	Apparently not different.
	Tap water				
.5 gm. tallow	15 "	.877%	40°C.	——	No clean up.
1.5 gm. "	15 "	do.	41°C.	——	Very little granln.
.5 cc. oleic.	10 "	do.	31°C.	——	For assay of fine sands.

897 The quantities used in above expts. were Ore 500 gms., water 1500 cc.

The products from the last experiment were:

Froth concentrates	242 gms.
Fine sands	55 "
Coarse sands	198 "

The coarse sands were cleaned on the placque by aeration giving:

Clean coarse sands	167 gms.
Concs. from coarse sands	31 gms.

Allowing for 10% insolubles in the concentrates by froth, the concentration in that product is about 87%.

Assay of fine sands:

	11% of ore treated.
Zinc	6.49%
Lead	12.64%
Insols.	61.35%
Silver	8 ozs., 16 dwts., 10 grs.

Giving a total concentration of—

Lead, 92%, Zinc, 94%.

The assay of froth concentrates from a previous experiment, weighing 170 gms. returned

Zinc 32.70
Lead 28.75
Insolubles 12.10
Concentration—Lead, 56%
Zinc, 69%

(813—94)

The froth was separated by stopping the cone removing it and th
baffle from the Gabbett, allowing the sands to settle for about
minutes then inserting a funnel so that it dipped into th
898 clear liquid, and pouring more water in, until the whole o
the froth was floated over the sides of the Gabbet into a bow
placed underneath for that purpose. This also floated over some fin
gangue which may account for the large percentage of insolubles i
the concentrates.

Experiments on the separation of the froth are being made b
so far no satisfactory method has been obtained.

A diminution of the percentage of oil when that oil is eith
paraffin or Balkhany crude oil, does not cause a similar frothi
to the oleic acid, but a diminution in the size of the granules and
increase in the time required for clean up of the sands.

Other oils excepting melted tallow, *the* which is of no use, ha
not yet been examined for froth in small percentages.

Some experiments have been made using the same sized cone as
the experimental Gabbets but a much larger vessel, i. e., 7⅜″
ameter and 7⅞″ deep, holding 4000 cc. of water and 1333 gms.
ore. Other conditions being the same as in the smaller vessel
periment the time had to be increased to clean up the sands. Th
evidently means that a worse proportion between the dimensio
of the vessel and the cone exist when the larger vessel is substitut
for the small one. Whether any proportion between the two or
the other side of the small one would give better results remains
be determined.

A. HOWARD HIGGINS. (814—95)

899 COMPLAINANTS' EXHIBIT SULMAN & PICARD REPORT, M
3, 1905.

Sulman & Picard, 44 London Wall, London, E. C.

Copies sent to C. F. Courtney & Geo. A. Chapman. 5-5-05.
Received 5-5-05.
Board 25-5-05.

3rd May, 1905.

John Ballot, Esq., Chairman, Messrs. The Minerals Separation, L
62 London Wall, E. C.

DEAR SIR: We beg to hand you herewith a statement of the
method of oil concentration which we have been engaged in inv

gating and working out in detail, for the purpose of your forwarding to Mr. Courtney and his staff in Australia.

It will be best to start with a short statement on the principle on which the process depends.

In determining the lowest limit of Oleic acid which could be employed in granulating, it was found that granulation practically stopped at a range of about 0.5% of Oleic acid on the mineral (60 mesh Broken Hill), in an acid circuit somewhat below 1% in strength.

A certain amount of black mineral froth was, however, noticed as a result. On successively decreasing the amount of Oleic acid below .5% it was found that whereas granulation ceased there was a growth in the amount of mineral float-froth under these conditions,
900 and that the production of such float-froth appeared to reach a maximum when about .1% of Oleic acid on mineral was used. This froth on collection was found to consist of oiled mineral slimes mechanically holding more or less coarse (oiled) mineral particles, the froth carrying (815—96) between 70 to 80% of the total mineral present in the charge. The gangue slimes and the coarse sands are left quite white in the liquor below the froth, and the balance of the coarse mineral not caught up in the black froth, but remaining mixed with the sands, is found to have been efficiently oiled and to be capable of complete recovery from the sands by table aeration.

This important discovery naturally suggests an economical method for the recovery of Broken Hill mineral quite different from any employed by you previously. The froth produced is not due to any action of the acid circuit upon traces of calcite present in the ore; i. e., not to the liberation of any gas in the charge by means of the dilute acid employed in the circuit.

It has been located, on the contrary, to the air introduced by the Gabbett cone during agitation, the air attaching itself to the oiled mineral slimes and to a large proportion of the coarse mineral particles, although both these materials can only be coated with an infinitesimal amount of oil, i. e., Oleic acid.

That the formation of froth is due to air inclusions during the agitation, and not to carbonic acid or sulphuretted hydrogen is proved by the following experiences:

901 (1) If it were due to gases other than air the froth should be as freely produced when .5% or more of Oleic acid is used; this is not the case, and goes to show that a minute proportion of Oleic acid is one of the factors in float froth production.

(2) Samples of 60 mesh ore have been agitated with the acid circuit liquor without oil, or Oleic acid, (816—97) for a sufficiently long period to have decomposed any trace of calcite, etc., present in the ore. On the addition of .1% of Oleic acid thereto, and agitation by the Gabbett cone, the froth is produced just as readily as if fresh ore was employed.

(3) Sulphuretted hydrogen in quantities sufficient to produce the frothy mass is conspicuous by its absence.

(4) Additions of whiting or of calcite to the original ore failed

to give any more definite froth than was obtained on the simple
without such admixture.

The production of froth is to some extent a factor depending u
the amount of mineral slimes present in the ore the samples of
which contain a minimum of slimes (such samples being carefu
powdered to 60 mesh, by "step by step" reduction, with careful tr
melling off of the fines produced at each crushing), were found
give a considerably less proportion of froth and to leave more co
mineral in the sands. Nevertheless such coarse mineral left in
sands was found to be quite sufficiently oiled, and to be recovera
by aeration upon the table.

902 It thus appears that whether a mineral sample crushed
60 mesh contains mineral slimes in large proportion, or
reverse, the use of .1% of Oleic on the ore is quite sufficient to aff
means of complete recovery.

In our experiments carried out in the single Gabbett mixer
emulsion of Oleic acid was used, but the latter was introduced fr
a burette, drop by drop, to the mass of pulp whilst in vigorous ag
tion. In these (817—98) experiments 500 grammes of ore were u
in about 1,500 c. c. of liquor of acidity varying from ½ to
of sulphuric acid, the whole being heated to temperatures vary
between 30° and 40° C.

The temperature factor is also a most important one in insur
efficient oiling ("oiling" in this case refers to Oleic acid) and
the production of froth. We now generally employ temperatu
varying between 35 to 40° C. to obtain the best results. The t
of agitation in the Gabbett also varies from 5 to 8 minutes, with
before stated proportions; during the agitation the formation
black mineral flocks can be traced even while the mass is undergo
rapid rotation. Directly agitation is stopped the black mineral f
froth rises rapidly to the surface, and on standing for a few secon
forms a layer of from 1 to 2 inches in thickness. Below this laye
seen the turbid white or pinkish white suspension of clean gang
slimes, the coarse sands, clean in themselves but containing so
coarse oiled mineral, remaining at the bottom of the mi

903 By careful addition of water beneath the float the black fr
(containing the bulk of the mineral present in the origi
charge) can be floated cleanly off over the edge of the mixer
recovered by draining or any suitable means. Should any sli
amount of froth sink during this floating off process, a slight stir
by hand of the contents of the mixer will at once bring to the sur
any such particles of sunk froth. The clean gangue slimes may
be poured off practically free from mineral, whilst the coarse sa
can be tabled, and their mineral contents completely (818—
removed by aeration.

A very large number of experiments was carried out on
method, and the process was then tried as a continuous one. A
several trials the type of apparatus illustrated in the accompany
sketch was arrived at, and is now giving excellent results (refer
diagrammatic sketch).

The plant consists of a series of Gabbett mixers fitted with

ual baffles, and speeded at from 1,000 to 1,100 revolutions per inute as regards the cone. These Gabbett mixers are identical in ery respect with those used for the original Cattermole process, the st one being provided with an automatic ore feed, water circuit let, and an oil (Oleic acid or Oleic soap solution) feed. It com- unicates with three other Gabbetts in which the agitation is con- nued as the pulp passes through them in series, the fourth mixer scharging by means of a swan-neck pipe into a short launder placed most horizontally and leading into a compound spitz-lutte sepa- rator. This spitz-lutte consists of three compartments, each 04 provided with a small water up current, and a means for col- lecting the material deposited in the apex of each, which may adapted as either continuous or intermittent. It is important to te that the junction ridge of each spitzkasten with the next is about to ¾ of an inch below the surface of the liquor filling the whole parator. This permits of a perfectly free travel from one end of e spitz-lutte to the other of the froth which separates from the pulp rectly the contents of the last mixer are discharged upon the short nder. (819—100)

It is also important that the launder leading to the spitz-lutte shall its point of entrance into the latter be perfectly horizonal, and actly on a level with the water line on the spitz-lutte. Any rippling tion which would otherwise occur would tend to sink some of the neral froth.

We may here conveniently note that other oils besides Oleic acid ay be employed in this modified recovery process, but so far as oken Hill is concerned Oleic acid gives by far the best results. troleum residuum added as emulsion, paraffine oil alone, R_2 P_1 d R_1 P emulsions, have also been used, and all give small pro- rtions of float, but do not act nearly so vigorously or efficiently on oken Hill ores as plain Oleic acid. Moreover .1% of Oleic acid the ore treated only amounts to some 6d. per ton, even assuming recovery of the Oleic acid, a question which we shall consider er.

Continuing the description of the apparatus. The Gabbett con- nts discharged into the launder are separated by the compound spitz-lutte as follows:

5 (1) The mineral froth which floats over the whole length of the spitz-lutte, escapes over an accurately rounded discharge n at its further end, into a launder, which delivers it on to any table filter surface; a piece of sacking or coarse, well-washed twill, all we have found necessary for this purpose.

(2) The heavy sands and all the balance of oiled mineral par- les sink in the first compartment of the spitz-lutte. Here a suffi- nt up-current of water is introduced to prevent fine sands or slimes tling with (820—101) the coarse sands and the mineral, the object ng to obtain a product which on tabling by aeration shall contain sands sufficiently fine to float off with the concentrates but to be anly and sharply delivered at the sand collection end of the table. reason of the increasing width of the spitz-lutte.

(3) The fine sands are therefore deposited and collected in the division of the spitz-lutte into which a small up-current is

also introduced. This up-current tends to keep the fine sands produ
free from gangue slimes and also to prevent the falling of any min
eral flocks from the float froth traveling over it, or to return suc
flocks again to the surface. Oftentimes the product settling in thi
second compartment, which is too fine to put over the table, has bee
found to be so free from mineral as to be capable of immediate re
jection. Should it, however, contain mineral, this can be easily re
covered by means to be described later.

906 (4) The third compartment of the spitz-lute also provided with a gentle water upcast, is sufficiently large to permit o the settlement of practically the whole of the gangue slimes, so that the water escaping over the lip of the spitz-lutte carries only clean mineral froth and is practically free from gangue slimes and quite clear.

We have obtained gangue slimes so free from mineral that they have been rejected without further treatment.

Clean up of second and third spitz-lutte products when these contain mineral. (821—102)

Both these products being too fine to put over the aeration table as they would naturally be floated over with the mineral on air treatment, are dealt with in one of two ways.

Their total quantity is relatively small compared with the produc which settles in No. 1 compartment and with the mineral froth re moved. Of course the joint amounts of Nos. 2 and 3 products wi depend upon the nature of the crushing initially adopted, but the may vary from as small an amount as 3% up to perhaps 10 o 15%. For clean-up purposes they may be mixed together.

Method A. This consists in simply again agitating in a separat Gabbett mixer, whereby any contained mineral, which is exclusively due to the sinking of a little froth mineral, is at once reliberated, and comes to the surface as float. This can be again recovered by passing over a small separate spitz-kasten. In some cases, however

907 although but very small amounts of material have been deal with, two or three agitations have been required to completely recover sunk froth. As the products are, however, generally so small in quantity a complete clean up is not a matter of economical urgency as a rule, and one agitation will probably be sufficient for all prac tical purposes.

Method B. A quick and complete recovery in one operation i possible by blowing a current of free steam into the mixed product suspended in a due proportion of circuit liquor. The combined heating effect of the steam with the bubbling product, completely sepa rates every trace of float mineral which rises to the surface as froth and when passed over another spitz-kasten (822—103) can be added to the bulk of the froth collected on the filter from the main operation.

The operations are therefore summarized as follows:

(1) Gabbett agitation in the usual way with .1% Oleic acid.

(2) Floating off the bulk of the mineral as froth free from sand and gangue slimes, on to a filter surface, the liquor from which at once returns to the main circuit.

(3) The collection of coarse sand and the balance of the miner

in No. 1 division of the spitz-lutte; the product separated going direct to the aeration table for final clean-up into coarse mineral and sharp clean sands.

(4) The fine sands and gangue slimes separated in divis-
908 ions 2 and 3 of the spitz-lutte are mixed and cleaned up either by fresh agitation or by the action of a jet of free steam, the mineral obtained as float froth thereby being added to the main froth product.

The return circuit passes through a heating apparatus to keep the temperature up to from 35 to 40° C.

Mode of Addition of Oleic Acid.—In the experiments first carried out in a single Gabbett mixer it was found that the Oleic acid could be added direct in the proper proportion without any previous emulsification, etc., but in the continuous plant this was found to be impossible, as three small drops of Oleic acid were all that was required for 60 grammes of ore according to the size of the burette drop which happened to be employed by us in our plant. Under these conditions we found (823—104) that some mineral was swept from the first into the second Gabbett without efficient oiling and that other portions of mineral were doubtless unduly oiled, owing to the insufficiently rapid break-up and dissemination of the oil drop.

Oleic acid emulsions in water are, as you are aware, unsuitable as they are difficult to prepare, are very unstable and require efficient agitation apparatus to keep them sufficiently mixed, and they tend to become thicker and un-uniform in flow after a short time. We have, therefore, returned to the use of Oleic soap solution with the best possible results. We employ merely a 1% solution of Oleic acid as soap, i. e., just neutralized with caustic soda. The degree of alka-
909 linity of this soap is so small that it is at once decomposed by the acid circuit, without perceptible diminution of the acidity of the latter; the result is that the Oleic acid is thus liberated throughout the mass of the pulp to be oiled in a state of the finest chemical division, and the most efficient and uniform oiling of the mineral particles is thereby insured. Further, instead of adding the Oleic acid at the rate of 2, 3 or 4 drops per minute to the Gabbett contents, 100 times this amount of Oleic soap solution is used, and permits of easy and exact regulation. We have thus obtained of late cleaner sands, and especially gangue slimes, than in any experiments where drops of straight Oleic acid were used.

This method also affords a further economy in Oleic acid, as both the float concentrates from the table and the float froth require to be "broken down," i. e., to have their Oleic acid removed by soda, as Oleic soap, (824—105) before they can be vanned into clean blende and galena products. The soap solution resulting from this break-down is all that is required for the initial oiling of fresh mineral by the above described process. The Oleic acid is therefore of necessity recovered in the process and in the state in which it is required for re-use. This is not undertaken merely for the purpose of recovering Oleic acid, but as a necessary step in rendering the concentrates fit for vanning separation into blende and galena.

One important point remains to be noted in the breaking-down operation.

The caustic soda solution used should not exceed 1% in strength and should be made up with soft, or rain water, i. e., which
910 shall be free from lime or other salts. Unless this precaution be observed the Oleic acid cannot be cleanly removed from the concentrates; as small amounts of insoluble calcium or other soaps remain mixed with the concentrates or attached as microscopic films on the mineral surfaces, and lead to considerable float losses when such imperfectly cleaned mineral is sought to be separated on the vanner or other table.

If the mineral products after breaking down be accurately sized to varying mesh, limits in a MacDermott or other sizer, we have obtained indications that separation into blende and galena may be obtained in upcast apparatus adapted to the varying products, instead of employing vanner tables; but we have not yet fully worked out this idea.

The size of the compound spitz-lutte employed by us in the above trials was 2 ft. 6 ins. in total length (825—106) 2 ins. in width at the narrow end, and about 20 ins. wide at the broad or discharge end. The three divisions were necessarily rhombic in top plan, but each was brought to a cone-shaped bottom, the depth of each one being such that the average slope of the sides was between 50 and 60° in order to insure no sand or other product resting upon them.

A further modification of the whole process may be as follows:

(1) The subjecting of the suitably crushed ore to a water grading separation into two products, the first product being sharp ore, the second containing all fine and slime ore. The subjecting the coarse ore to plain air flotation clean-up in an acid circuit on an
911 aeration table without the addition of any oil or Oleic acid.

(2) The before-described oil and frothing method to be applied to the fine grade material in the manner before detailed. In any event, and whichever method be adopted, the consumption of Oleic acid is now reducible to an absolute minimum and need not exceed at the outside a very few pence per ton.

It will be obvious from what has been said as to the necessary recovery of Oleic soap that the limitation of Oleic acid to .1% is by no means essential, and if better frothing and oiling of mineral is insured under Australian conditions by employing .2 or even .3% of Oleic acid in place of the .1% herein described, these amounts can be safely employed as they are recoverable to at least from 80 to 90%.

Standard large scale runs are in progress on both (826—107) methods, but we regret that we shall not have weights and assays of products in time for despatch to Australia by this mail.

The efficiency of the process hardly requires these assay figures, as the cleanness of the products from mineral is sufficiently evident.

We are, dear sir,

Yours truly,

SULMAN & PICARD.

912 COMPLAINANTS' EXHIBIT CABLE HYDE TO HOOVER, JANUARY 20, 1910.

The Anglo-American Telegraph Company.

SAN DIEGO, CALIFORNIA.

To Mineration, London.

Hoover	
Canjearson	Western Union Code
caperolan	Can come
fludiabunt	one month (?)
consension	very desirable
bevisichte	on private affairs (?)
fumidi	provided the opportunity is not lost
burenque	Can you
dissaeptos	telegraph funds to meet immediate expenses.

JAMES M. HYDE.

COMPLAINANTS' EXHIBIT CABLE HOOVER TO HYDE, JANUARY 21, 1910.

Jan. 21, 1910.

To James M. Hyde:

£100 will be telegraphed if you can leave during next week. (827—108)

913 COMPLAINANTS' EXHIBIT CABLE, HYDE TO HOOVER, JANUARY 24, 1910.

The Anglo-American Telegraph Company.

PALO ALTO, CALIFORNIA, Jan. 24, 1910.

"Via Anglo."

To Mineration, L'd'n.

Hoover	
exertment	will leave
Klemhaken	during this week
dissaeptos	telegraph funds to meet immediate expenses
to	to
Sandiego	San Diego.

JAMES M. HYDE.

COMPLAINANTS' EXHIBIT SULMAN & PICARD REPORT, FEBRUARY 24, 1910.

24th February, 1910.

John Ballot, Esq., Chairman of the Minerals Separation, Ltd., 62 London Wall, E. C.

DEAR SIR: We beg to report on research work we have done in connection with mineral flotation during the past two or three months.

* * * * * * *

In carrying out investigations on the above lines we found the need of a frothing apparatus which would separate the froth
914 sharply from the settled gangue without the use of spitzkasten plant, which is never satisfactory on the small scale for a sharp clean-up. We constructed several forms of apparatus, but finally adopted the sliding top-principle with an electrically underdriven agitator; this has proved a most excellent plant, and has been inspected by your Mr. Hoover. Mr. (828—109) Sydney Stevens has recently worked it and expresses complete satisfaction with it. It would be well to have this construction in a larger size, and this we believe Mr. Hoover intends doing.

We may mention that simple as are the details apparently it took us a month or more to effectively work out.

* * * * * * *

We are, dear Sir,

SULMAN & PICARD.

COMPLAINANTS' EXHIBIT LETTER, MINERALS SEPARATION TO HYDE, MARCH 2, 1910.

Dictated to M. E. P. by J. B.
Enclosures.

Minerals Separated, Limited,

62 LONDON WALL,
LONDON, E. C., 2nd March, 1910.

James M. Hyde, Esq., 62 London Wall, E. C.

DEAR SIR: As explained to you, a private syndicate has been formed in connection with my Company, for the special pur-
915 pose of exploring the Republic of Mexico, with a view to finding mines, ores, dumps or tailings, preferably amenable to profitable treatment by the Minerals Separation processes—and to endeavour to acquire such mines, ore dumps, or tailings wholly or in part, if such can be done on sufficiently advantageous terms, or to secure the adoption of Minerals Separation processes by mine owners under royalty, in cases where a direct interest (829—110)

cannot be acquired—and if successful to form a larger Company to handle the interests so acquired.

To give effect to this, and after fully discussing the policy with your good self, it has been agreed to retain you to give your services exclusively to make the necessary investigations in Mexico, and carry out the object and intention of the Syndicate to the best of your ability, on the following terms and conditions.

That you will, as soon as directed, proceed to the City of Mexico, and, after conferring with the Syndicate's agents and friends there, devote the whole of your time and your best endeavours to carry out the work and without delay visit all the most likely districts and individual mines in the Republic, or such mines and districts as you may from time to time be directed to do, and carefully inspect their ores, dumps, etc., to ascertain quantity in sight, the value by careful sampling and treatability by Minerals Separation process as far as that may be possible, with the field apparatus you will be provided with. You will also ascertain, as far as possible all local con-
916 ditions governing labour, supplies, transport, market for products, water, fuel, power, etc., which may have a bearing on the possibilities of successful mining or treatment operations.

You will fully, faithfully and concisely report in writing all results and information, so soon as obtained, together with your views and recommendations, direct to the Syndicate, or to the Chairman of Minerals Separation, Ltd., 62 London Wall, London, E. C.; in all other respects all such information obtained shall be retained by you in strictest confidence and shall not be (830—111) communicated or disclosed to anyone, except on written authority from the Syndicate, Messrs. Lazard Bros., or the Chairman of Minerals Separation, Ltd.

If any property, or properties, are found which you consider likely to suit the purpose of the Syndicate and for that reason to be worth further investigation, it may be desirable, in addition to such investigation, to arrange to send to England a bulk sample of the average ore for test and treatment, which you will accordingly arrange for and consign to Minerals Separation, London, through Messrs. Lazard Bros., of Mexico City, or as they may direct.

For the purpose of this undertaking, and to enable you to test ores on the spot, Minerals Separation will disclose to you its various processes, and give you all information in connection therewith, you undertaking to keep all such information confidential, and not to make use of any of it for any purpose except that of the Syndicate, and further you undertake and agree to communicate to that
917 Company (Minerals Separation) any ideas for the improvement, modification, or addition to the processes, mechanical or otherwise which may occur to you, or which you may make, and such shall be the sole property of the Minerals Separation, and you will immediately, or whenever called upon, sign all documents necessary to protect the same by patent, if so desired, and convey the title to that Company by assignment or otherwise.

The agreement shall be for a period of one year from 1st Feby. 1910, the Company reserving the option to continue your services

for another year on terms to be mutually agreed upon. (831—112)

The consideration for the services to be rendered by you shall be at the rate of £1,000 per annum, payable monthly, or quarterly, as you may desire. The Syndicate shall also pay all your reasonable travelling and other expenses connected with the business—of which proper account shall be kept, and rendered monthly or quarterly, it being understood that such traveling and other expenses shall be kept within the limits, justified by the spirit and intention of the expedition.

In the event of any desirable business offering you shall actively assist any of the Company's or Syndicate's agents, or representatives, in carrying on any negotiations for dealing with or acquiring the same—no definite or binding negotiations for properties to be undertaken by you without the Syndicate's authority—nor are you in any way to commit the Company or Syndicate to an un-
918 dertaking or responsibility without their previously obtained written authority.

If you accept the engagement on the foregoing terms and conditions, I am authorized to confirm the agreement for and on behalf of the Syndicate, in the name and for and on behalf of Minerals Separation, Ltd.

I am, dear Sir,

Yours faithfully,

JOHN BALLOT,

For and on Behalf of Minerals Separation, Limited.

(832—113)

COMPLAINANTS' EXHIBIT HYDE ACCEPTANCE, MARCH 3, 1910.

Minerals Separation, Limited.

62 LONDON WALL,
LONDON, E. C., 3rd March, 1910.

John Ballot, Esq., Chairman of the Board of Directors, Minerals Separation, Ltd., 62 London Wall, London, E. C.

DEAR SIRS: I have received your letter of March 2nd, 1910, for which I thank you, and I hereby accept employment with the Minerals Separation, Ltd. on the terms mentioned therein and in the cables between T. J. Hoover and J. M. Hyde dated January 18th, 20th, 21st and 24th, 1910.

I am, dear Sir,

Yours truly,

JAMES M. HYDE. (833—114)

919 COMPLAINANTS' EXHIBIT NUTTER REPORT, DECEMBER 3, 1910.

Dictated to E. N. P. by E. H. N.
Enclosure 1.

Minerals Separation, Limited.

62 LONDON WALL,
LONDON, E. C., 3rd March, 1910.

The Board of Directors, Minerals Separation, Limited, 62 London Wall, E. C.

DEAR SIRS: I transmit herewith a paper entitled "Technical Development of Minerals Separation Process," which is the last of the Reports based on my trip to Broken Hill.

Very truly yours,

EDWARD H. NUTTER.

Technical Development of Minerals Separation Process.

It will be hardly accurate to refer to this paper as a report as it is almost necessarily an argumentative discussion embodying my personal views concerning the relative importance of the various unsolved problems, and the most promising lines of investigation leading to their solution.

One of the most important group- of problems is that concerned with the development of the best design of plant for carrying
920 on the essential operations which go to make up the Minerals Separation flotation process. It is to be understood of course, that no design can be completely worked out in advance that will be suitable for all ores, or for any ore. The different parts of the general problem will have different weights in the different (834—115) cases, and the relative importance of the different operations will hardly be the same at any two mines. In other words each ore presents a separate problem to us as well as others. It is safe to say that there have been more metallurgical failures as a result of lack of appreciation of this general truth, than could be traced to any other cause. It is important however to crystallise our knowledge into rules for estimating the weights of the different variations to be met with as much as possible, so that we need take the minimum of time in working out a design to meet particular conditions. Thus, given a complete analysis of an ore and assays of the different sizes of a finely crushed sample of it, we should be able to tell approximately what we could do with it as soon as we get a few small scale results. Before the last word can be said as to what is the best standard design of a plant, a lot of experimental work will have to be done, and new apparatus designed or invented.

* * * * * * *

We should get also a coarse middling, and a slimy tailing, consisting probably of unsaleable mixtures of the two sulphides. The commercial efficiency of such an application of the process to any particular ore, would depend on the ratio between the saleable
921 and unsaleable products. If the amount of middlings was too great, we would have three courses open. One, the taking off of partial products in the first instance, and tabling these separately. Should this leave too much coarse mineral in the coarse tailings as a result of robbing the pulp of the fine sulphides at an early stage, we could instead take all the sulphides off, leaving a clean tailing, (835—116) and then retreat the concentrate, dividing it into partial products which could be tabled separately or not, as desired. An alternative scheme to this would be to fix the conditions of the first flotation so that a maximum of copper would come off with as little zinc as possible. A retreatment of this product by flotation could be expected to give a fairly clean copper concentrate and a zinc reject containing some copper which could go back to the first set of mixers.

* * * * * * *

Part of the material we would take off would be in the form of clean concentrates and part as dirty concentrates, which would need retreatment. In differential work all of the products would probably be retreated separately.

There are a number of sound reasons for the belief that a combination of partial products flotation and retreatment of the separate products by ordinary concentrators would be the easiest and quickest way to a solution of the problem of separating the minerals in complex ores.

* * * * * * *

While in many cases it may be found better work above
922 atmospheric temperatures the cold circuit should be found useful in such ores as make for high acid consumption. The criterion in all cases will of course be the balance between increased extractions on the one hand, and increased costs on the other. It seems probable that one retreatment of dirty concentrates would be sufficient to eliminate practically all the contained gangue as 15% insoluble could be reduced to about 1% aside from chats, at a single retreatment. (836—117)

* * * * * * *

Design of Plant.—The material coming for treatment to a Minerals Separation plant will have originated in one of three ways. First, it will be finely ground crude ore, of which the preliminary treatment has been for the purpose of preparing it for Minerals Separation treatment. Second, it will be finely ground ore, which has already been subjected to treatment for the recovery of one or more minerals, and is sent on to the Minerals Separation process for further treatment. Third, it will be tailings which has resulted from

milling operations in the past and been stacked; and has to be excavated, transported to the plant prepared for treatment, and treated.

* * * * * * *

I think that any plant erected for the treatment of such disseminated copper ores will have to consist of mixers and spitzkasten, for taking off the concentrates, followed by mixers and traps for sweeping up all possible remaining values from the ore. The
923 traps would probably deliver this product to regrinding apparatus, which would in turn deliver to the head mixer again. The concentrates from the spitzkasten would probably be delivered direct to retreatment mixers where more water would be added and a clean low silica concentrate taken off. The tailings from these retreatment mixers and spitzkasten would go to regrinding apparatus, or to the head mixer again, depending on the nature of the material.

* * * * * * *

(837—118)

COMPLAINANTS' EXHIBIT CABLE MINERALS SEPARATION TO HYDE DECEMBER 8, 1910.

Canadian Pacific Railway Company's Telegraph.

Via Toronto
From London, 8 Dec., 1910.

To Jamehyde, Sudbury, Ont:

ugparzuow	Re your wire of 7th Curle
tubogjouhb	still in
klehzuzfop	movements uncertain
epgemakdra	Do not alter
wuselosjog	your present
okonb .	program.

924 COMPLAINANTS' EXHIBIT CABLE HYDE TO MINERALS SEPARATION, DECEMBER 9, 1910.

Cable to Mineration via Ottawa, Dec. 9, 1910.

Jiero—	re your letter of the 23rd ult.
ugpes—	re your telegram of the 8th
wueng—	you are
atybe—	fully aware that
hyawn—	I would not
divco—	contract for
kitya—	more than
layne—	one
wubar—	year

guacf—	
huyob—	I shall be
kukib—	New York
ebbre—	in a few days (838—119)
uhkun—	telegraph to me
ukphe—	there
huded—	how
alavk—	and
wecky—	when you
olgel—	propose to
anuzk—	arrange for
guety—	future
woirg—	work

925 COMPLAINANTS' EXHIBIT HYDE REPORT, JANUARY 8, 1911.

The North American Situation.

The situation with regard to the possibility of doing business in North America, in so far as it has been possible to consider it during the past year, is in substance as follows:

Mexico.

* * * * * * *

Canada.

* * * * * * *

United States of America.

Districts.

Among the districts of promise in the United States are the following:

The Butte district of Montana in which large deposit of zinc sulphide ores, needing concentration, are being (839—120) developed and in which are being mined and concentrated an enormous tonnage of sulphide copper ores which if amenable to flotation treatment should offer large possibilities of royalty business.

* * * * * * *

At the present time it seems wise to investigate the Butte district first, as that is the region of greatest apparent promise and in which it is probable that results can be most rapidly attained.

8/1/11.

JAMES M. HYDE.

926 COMPLAINANTS' EXHIBIT COPY MEMORANDUM RE MANAGERSHIP OF MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED.

Memorandum Re the Managership of Minerals Separation American Syndicate, Ltd.

The mining fields of the North American Continent are of great extent, varied nature and vast possibilities. They offer great opportunities for the exploitation of the Minerals Separation Ltd's patented flotation processes.

There are three factors upon which the success of ventures of the class being undertaken depends—the processes, the capital with which to exploit them, and the executive and creative business capacity of the manager.

The position of manager of the Minerals Separation American Syndicate Ltd. involves great responsibilities and the most varied and most taxing variety of duties and functions which will have to be exercised in connection with reaping the possible advantages of flotation processes. The success of the venture will be contributed to (840—121) as largely by the capacity of the manager as by any other factor. It will in fact be absolutely dependent upon his scientific knowledge, technical experience, adaptive ability, and creative and executive capacity. Any man possessing such abilities must be fully conscious of his qualifications and powers and of their commercial value. No man possessing such capacity will consider
927 investing his energies in enterprises in which he is not adequately compensated for his time, and also allowed to create for himself an estate, by a just participation in the results of his labors. No mere salary, or salary combined with any terminable form of profit sharing can adequately compensate such a man for the expenditure of his business-creative ability.

In order for the position of manager of the Minerals Separation American Syndicate to be acceptable to me it would have to carry the following considerations.

1st. The manager should be empowered to draw up and carry out the plan of campaign, to hire and discharge employees necessary in the work, to instal testing facilities, when desirable (in connection with the Minerals Separation Ltd.'s technical staff), to conclude leases and options on properties, or purchase raw materials where such transactions do not involve an expenditure or obligation of more than a certain fixed sum, say £1000, it being however understood that whenever reasonable (and no delay being thereby caused to the Syndicate in the Manager's opinion) authority should be obtained from London for all transactions involving cash payments or obligations (841—122) exceeding £500.

2nd. The position should not be considered to be subordinate to any appointive officer of Minerals Separation, Ltd.

3rd. The salary should be such as similar engineering and busi-

ness service usually commands and in no case less than
928 received by any other technical man connected with the e
ploitation of the Minerals Separation Ltd. processes.

4th. As partial compensation for creating the American busine the manager should receive a two years' free option upon the righ to subscribe at par, or issue price, to ten per cent of the capital stoc of the Minerals Separation American Syndicate, and all busine resulting on the American Continent from the use of the Mineral Separation processes, or contributed toward or undertaken by th Minerals Separation Ltd., the Minerals Separation American Syndi cate Ltd., or any offshoot from them launched during the term o office of the manager.

5th. All mining and milling propositions of sufficient promis shall be submitted to the directors for their consideration. The manager shall be considered at liberty to deal in his own interest a he may see fit, with any proposition not considered as desirable as a Minerals Separation American Syndicate Ltd. venture by the Boar of Directors.

6th. There shall be a regular and prompt consideration of al communications submitted to the London office, and some officia or officials shall be designated to regularly inform the manager o the results of such consideration, (842—123) and to discuss th matters treated of in such communications with him.

929 COMPLAINANTS' EXHIBIT LETTER HYDE TO MINERALS SE ARATION AMERICAN SYNDICATE, JANUARY 17, 1911.

62 LONDON WALL, LONDON, E. C.,
17th January, 1911.

Mr. John Ballot, Chairman, Minerals Separation American Syndi cate, Ltd., 62 London Wall, City.

DEAR SIR: I hereby withdraw the "memorandum re the man agership of the Minerals Separation American Syndicate" which I placed in your hands a few days since. I have determined that it i not wise for me to contract with your Company for another year.

I have in my possession a variety of articles used in my work which were purchased with the funds of the Mexican Syndicate. These I will turn over to whomsoever you may indicate. A portion of them are now in London, others are in my trunk in New York, while others are packed with some of my personal effects in a box stored in Canada.

My expense account, when presented, will include the cost of my return to California.

It is possible that while engaged in exploratory and metallurgical work in the United States, I may have opportunity to use a flota tion process, or to recommend the adoption of one by some going concern. Will you kindly inform me as to the royalty you have decided to ask in (843—124) America and the commission
930 you are willing to pay on royalty business brought to you.

Respectfully yours,

JAMES M. HYDE.

COMPLAINANTS' EXHIBIT LETTER MINERALS SEPARATION TO HYDE, FEBRUARY 1, 1911.

Dictated to M. E. P.
By J. B.

Minerals Separation American Syndicate, Limited.

62 LONDON WALL,
LONDON, E. C., 1st Feb., 1911.

J. M. Hyde, Esq., c/o H. C. Hoover, Esq., 1 London Wall Buildings, E. C.

DEAR SIR: In further reference to your letter of the 17th ult. and as personally explained on several occasions, I regret that you have decided not to extend your engagement with our Company for another year.

With regard to the various articles belonging to the Company in your possession, I shall be pleased, as already arranged beween us, if you will have these delivered to Messrs. Beer-Sondheimer & Co. of New York for our account, and they will pay any expenses for freight, forwarding, etc. thereon. We believe they have an agency at Salt Lake City as well, and so soon as we get the address from them, we shall be glad to forward it to you, should that centre be more convenient to you.

As you say, it is possible that while engaged in (844—125) 931 exploration and metallurgical work in the United States, you may have the opportunity to use our Flotation Process, or to recommend the adoption of the use of same to some going concerns. We wish to assure you that we shall be glad to consider any such business proposals on their merits as they come along, when the question of terms, either by royalty or otherwise, and also your commission for the introduction thereof, will be gone into at once and mutually arranged.

I am, dear Sir,
Yours truly,

JOHN BALLOT,
For and on Behalf of Minerals Separation, Limited.

COMPLAINANTS' EXHIBIT EXTRACT FROM RICHARDS ORE DRESSING.

SEC. 869. Settling Fine Slimes by Means of Dissolved Substances and by Heat.

In sampling mill products that contain slimes carried in water it should be remembered that the extremely fine particles may not settle in several days or even weeks. However, there are various substances, small quantities of which dissolved in the water will coagulate the particles into comparatively large grains, which settle rapidly. Such a substance should be used in every important case, for the fine slimes are apt to contain a large percentage of the value, al-

though they may be very small in weight. At one mill where th
samples were allowed to settle only a short time before pouring o
the (845—126) water, assays of the tailings indicated 8
932 8½ ounces of silver per ton, but when the slimes were tho
oughly settled, the tailings assay was found to be 18 ounc
of silver per ton.

The following experiments, made in the author's laboratory, gi
some exact results with the use of lime, alum, common salt, hydr
chloric acid and sulphuric acid. The slimes were obtained by stamp
ing a quartz ore from North Brookfield, Nova Scotia, containing som
slate, a fractional percentage of arsenopyrite and some free gold
using a punched screen with slots 1/40 inch wide and a height o
discharge of 4 inches. After passing over amalgamated plates and
a vanner, the coarse portion was settled out in small tanks, while th
finest slimes were carried into a larger tank from which the wate
was pumped back to the stamp mill and used again. After the mil
run was finished and the water had remained quiet in the large set
tling tank for half an hour, a large sample of the slimy water wa
taken from the top of this tank. Fifteen careful tests showed a
average of 12.8% suspended matter, the extreme variation bein
from 12.3% to 13.0%. The results, given in Table 394 are based o
this average. The tests were made on one liter quantities in beak
ers of such size that the water stood 6½ inches deep in them.

933 TABLE 394.

Effects of Dissolved Substances in Settling Fine Slimes.

* * * * * * *

Time of Settling.	Sulphuric Acid.		
	0.15%	0.29%	0.57%
½ hour	100	96	99
14 hours	99	—	—

(846—127)

COMPLAINANTS' EXHIBIT ASSIGNMENT FROMENT TO BALLOT, NOVEMBER 17, 1903.

No. 12778/1902.

This indenture made the seventeenth day of November One thousand nine hundred and three between Alcide Froment of Traversella in the Kingdom of Italy Engineer (hereinafter called the Vendor) of the one part and John Ballot of Salisbury House, Finsbury Circus in the City of London Esquire (hereinafter called the purchaser) of the other part whereas His Gracious Majesty King Edward VII by Letters Patent under the Seal of the Patent Office bearing date the Fourth day of June One thousand nine hundred and two and numbered 12778 did for himself, his heirs and

cessors give and grant unto Henry Harris Lake of 45 Southampton Buildings in the County of Middlesex Patent Agent his executors, administrators and assigns, especial license, full power, sole privilege and authority to make, use, exercise and vend an Invention of "Improvements relating to the Concentration of Ores" within the United Kingdom of Great Britain and Ireland and Isle of Man, during the term of Fourteen Years from the day of the date of said Letters Patent, subject to the conditions in said Letters Patent contained. And whereas the said Letters Patent were granted to the said Henry Harris Lake on behalf of the Vendor as a communication from abroad. And whereas by an Indenture dated the 13th day of November 1903 and made between the said Henry Harris Lake of the one part and the Vendor of the other part the said Letters Patent and the full benefit thereof were duly assigned to the vendor as in said Indenture mentioned. And whereas the Vendor has agreed with the purchaser to assign (847—128) unto him all his right title and interest in and to the said invention in the manner hereinafter contained. Now this indenture witnesseth that in pursuance of said agreement, and in consideration of the sum of Two hundred and twenty five pounds sterling on or before the execution of these presents to the Vendor paid by the Purchaser (the receipt whereof is acknowledged) he the Vendor doth hereby as beneficial owner assign and convey unto the Purchaser his executors, administrators and assigns all those the said invention Letters Patent and premises hereinbefore mentioned, with all profit, benefit, commodity and advantage therefrom arising to hold the same during all the residue of the term of said Letters Patent, or any prolongation of the said term, unto the Purchaser his executors, administrators and assigns, for his and their sole use and benefit. Together with all improvements in the said invention which the Vendor may either by himself or in conjunction with any other person or persons invent or discover and the right for the Purchaser his executors, administrators and assigns to take out patents or other protection for the said invention or for any such improvements as aforesaid in any country colony or place except in the Kingdom of Italy that the Purchaser his executors, administrators or assigns may deem requisite or advisable. And the Vendor hereby covenants with the Purchaser that he the Vendor will forthwith forward or hand to the Purchaser the plans and diagrams of the plant relating to the said invention with a full description of the working of the process and that he the Vendor will from time to time forthwith communicate to (848—129) the Purchaser his executors, administrators or assigns each and all such improvement or improvements as aforesaid and will in like manner forward or hand to the Purchaser his executors, administrators or assigns the plans and diagrams of the plant relating to such improvement or improvements with full descriptions of the working of the same and that he will give to the Purchaser his executors, administrators and assigns the benefit of his advice in relation to the said invention and to any such improvement or improvements as aforesaid as and when the same may be required. And further that he the Vendor will from

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time to time and at all times hereafter make such declarations and execute and sign such deeds and documents and do such other acts and things as may be required by the Purchaser his executors, administrators or assigns for obtaining such further Patents or other protection as aforesaid and for vesting the same and the full benefit thereof in the purchaser his executors administrators and assigns and the Vendor hereby covenants with the Purchaser that notwithstanding any thing by the Vendor done, executed or omitted or knowingly suffered the said Letters Patent are [valid and]* subsisting [and in no wise void or voidable].*

936

Nine words are struck out.

A. F.
J. B.
F. C.

In witness whereof the said parties have hereunto set their hands and seals the day and year first above written.

A. FROMENT. [SEAL.]

Signed, sealed and delivered by the said Alcide Froment in the presence of

G. B. ZANARDO,
9 *Via Due Macelli, Rome.*

Before me,

F. COSSIRINI,
British Proconsul.

(849—130)

JOHN BALLOT. [SEAL.]

Signed, sealed and delivered by the said John Ballot, in the presence of.

G. B. ZANARDO,
9 *Via Due Macelli, Rome.*

Before me,

F. COSSIRINI,
British Proconsul.

[* Words and figures enclosed in brackets erased in copy.]

937 COMPLAINANTS' EXHIBIT FROMENT ITALIAN PATENT.

Provi. de Rome.

Regro Genle Vole 43, No. 63723.
Regro Attes. Vol. 156, No. 166.
Description de l'invention ayant pour titre:
Procédé pour l'enrichissement des minerais sulfurés cuivreux, plombeux, blendeux, etc. par les gaz combinés aux corps gras

par:—

Mr. Ing. Alcide Froment a Traversella (Italic).

Les phénomènes suivants étudiés par l'inventeur, ont servi de base au procédé dont il est cas:

1. Lorsque les sulfures naturel réduits en poudre fine sont mouillés par un corps gras, ils ont une tendence à se réunir en sphérules et à venir flotter à la surface de l'eau.

2. Cette tendance est simplement retardée par le poids spécifique et contrariée par la gangue qui imprisonne les sulfures mouillés dans sa masse pulvérulente. (850—131)

3. Si un gaz quelconque se degage dans cette masse, les bulles de ce gaz se recouvrent d'une enveloppe de sulfures lesquels s'élèvent facilement ainsi au dessus du liquide pour y venir former une espèce de magma métallique.

4. La formation de ces sphérules métallique est singulièrement activée si le gaz est à l'état naissant.

Ainsi par exemple, si dans un tube à éssais nous mettons une dizaine de grammes de minerai de cuivre sulfuré avec sa
938 gangue, ungramme de calcaire, le tout réduit en poudre, si nous y ajoutons 30 grammes d'eu, quelques jouttes d'acide sulfurique et une mince couche d'huile ordinaire, si nous agitons pendant une seconde, nous verrons toute la chalcopyrite monter instantanément au dessus du liquide et serrées les unes contre les autres, les sphérules métalliques viendront se grouper en magma nettement séparé du reste du liquide. Si le calcaire est en excés ou de facile attaque, la rapidité de la séparation est tellement instantanée que la chalcopyrite est projetée avec force hors du récipient. Il y a donc une mesure a chercher pour un minerai et un calcaire donnés.

Le peu de gangue entrainée mécaniquement retombe peu à peu et les sulfures restent à l'état de pureté presque complète. Cel est le principe.

Donc, la rapidité de la formation des sphérules et leur ascension est en raison directe de la quantité de gaz produit en un même temps.

Exemple 1. Un minerai cuivreux contenant 12% de chalcopyrite 15% de pyrite de fer, 20% de carbonate de (851—132) fer, 16% de dolomie et de calcite et 37% de gangues diverses, à été soumis au

procédé dont il est cas. Il est à noter que ce minerai n'avait pu être enrichi économiquement par aucun moyen connu.

Il a suffi de quelques secondes seulement pour que le sulfure de cuivre soit complètement séparé du reste de la gangue dons laquelle l'analyse n'a pu déceler aucune trace de cuivre.

939 Exemple 2. Un minerai calciteux à 10% de plomb, invendable avec cette teneur, à été ainsi traité avec le même succès. Il y a plusieurs opérations distinctes mais liées dans lo pratique lue procédé: formation des sphérules et leur séparation de la gangue. Puis, separation du concentré d'avec l'huile et récupération de cette derniere qui ventre dans le circuit. Les concentrés se trouvent sous forme de tourteaux.

Revendication.

Je revendique donc comme ma propriété exclusipe et entière un procédé qui consiste à enrichir les minerais sulfures ou autres, minerais graphiteux et dérivés, terres sulfureuses ou autres à l'aide des gaz quels qu'ils soient combinés avec un corps gras oléifiant (et non avec un corps huileux dérivé des bitumes, goudron, naphte, etc.) et quelque soit l'appareil dans lequel ce procédé puisse être appliqué.

Roma, 20 Maggio, 1902.

p. p. Ing. ALCIDE FROMENT,
G. B. ZANARDO.
Il Segratario,
E. LIVONI.
Il Direttore Capo della Division I,
F. LANUSOL.
(852—133)

940 COMPLAINANTS' EXHIBIT TRANSLATION OF FROMENT ITALIAN PATENT.

Regro Genle Vole 43 No. 63,723.
Regro Attes, Vole 156 No. 166.

Description of the Invention Having for Title a Process for Enriching Sulphide and Copper Ores, Lead Ore and Blende by Gases Combined with Fatty Bodies,

by

Mr. Ing. Alcide Froment, of Traversella, Italy.

The following phenomena, studied by the inventor, have served as the basis of the process which forms the subject of this invention.

1. When the natural sulphides reduced to fine power are moistened by a fatty substance, they have a tendency to unite in spherules and to float upon the surface of water.

2. This tendency is simply retarded by the specific weight, and

opposed by the gangue which imprisons the moistened sulphides in its pulverulent mass.

3. If a gas of any kind is generated in this mass, the bubbles of this gas become covered with an envelope of sulphides and thus rise readily to the surface of the liquid where they form a kind of metallic magma.

4. The formation of these metallic spherules is singularly active, if the gas is in a nascent state.

Thus for example, if in a test tube there is placed ten grammes of sulphuretted copper ore with its gangue, a gram of limestone,
941 the whole reduced to powder, and if there is added thereto 30 grammes of water, a few (853—134) drops of sulphuric acid and a thin layer of ordinary oil, and the mixture then agitated for a second, the whole of the copperpyrite will instantly rise to the top of the liquid. The metallic spherules pressed one against the other, will become grouped in a magma clearly separated from the remainder of the liquid. If the limestone is in excess or readily attackable, the rapidity of the separation is so great that the copperpyrite is forcibly ejected from the vessel. Therefore, a correct proportion has to be found for a given ore and a given limestone.

The small quantity of gangue mechanically entrapped gradually falls and the sulphides remain in a state of almost complete purity. Such is the principle.

Accordingly, the rapidity of the formation of the spherules and their ascension is in direct ratio to the quantity of gas produced in a given time.

Example 1.

A cuprous ore containing 12% of copperpyrite, 15% of iron pyrite, 20% of corbonate of iron, 16% of Dolomite and Calcite and 37% of various gangues have been submitted to said process. It should be stated that this could not have been enriched economically by any known means.

Only a few seconds were necessary for completely separating the sulphide of copped from the rest of the gangue in which no single trace of copper could be discovered by analysis.

942 ### Example 2.

A calcitous ore having 10% of lead and unmarketable with such a proposition, has been treated in the same manner and with the same success. There are several (854—135) distinct but connected operations in the practical working of the process; the formation of the spherules and their separation from the gangue, then separation of the concentrate and the oil and recovery of this latter for re-entrance into the circuit of operations. The products of the concentration form oil cakes.

Claim.

I therefore claim as being my exclusive and entire property a process consisting in enriching sulphide and other ores, graphiteous

ores and their derivatives, sulphide earths or others, by means of gases whichever they may be, combined with an oily fat body (and not with an oily body derived from bitumens, tar, naphtha, etc.), and whatever may be the apparatus in which this process could be applied.

Rome, May 20, 1902.

ALCIDE FROMENT,
By G. B. ZANARDO, *Attorney*,
By the Secretary, E. LIVONI,
The Head Director of the First Division,
F. LANUSO. (855*—136)

[*Memo. of Clerk U. S. District Court: "Dating stamp jumped these numbers": 856, 857, 858, 859, 860, 861, 862, 863, 864, 865.]

No 759
MINERALS
Separation, Ltd. et al.
v.
HYDE.
Page
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No. 835,120. PATENTED NOV. 6, 1906.

H. L. SULMAN, H. F. KIRKPATRICK-PICARD & J. BALLOT.

ORE CONCENTRATION.

APPLICATION FILED MAY 29, 1905.

3 SHEETS—SHEET 1.

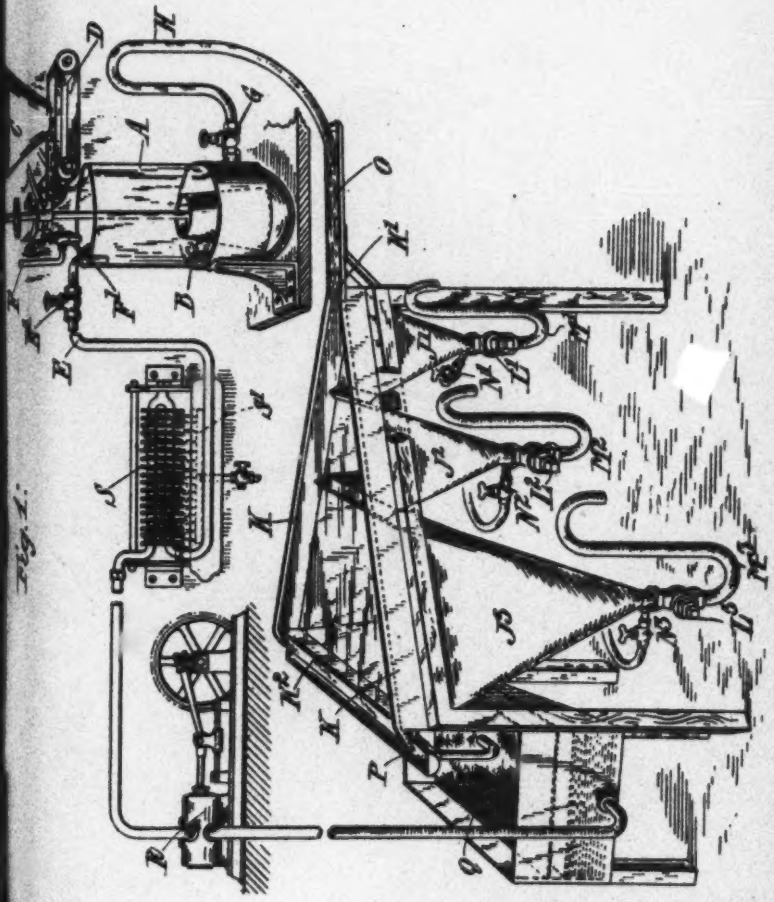
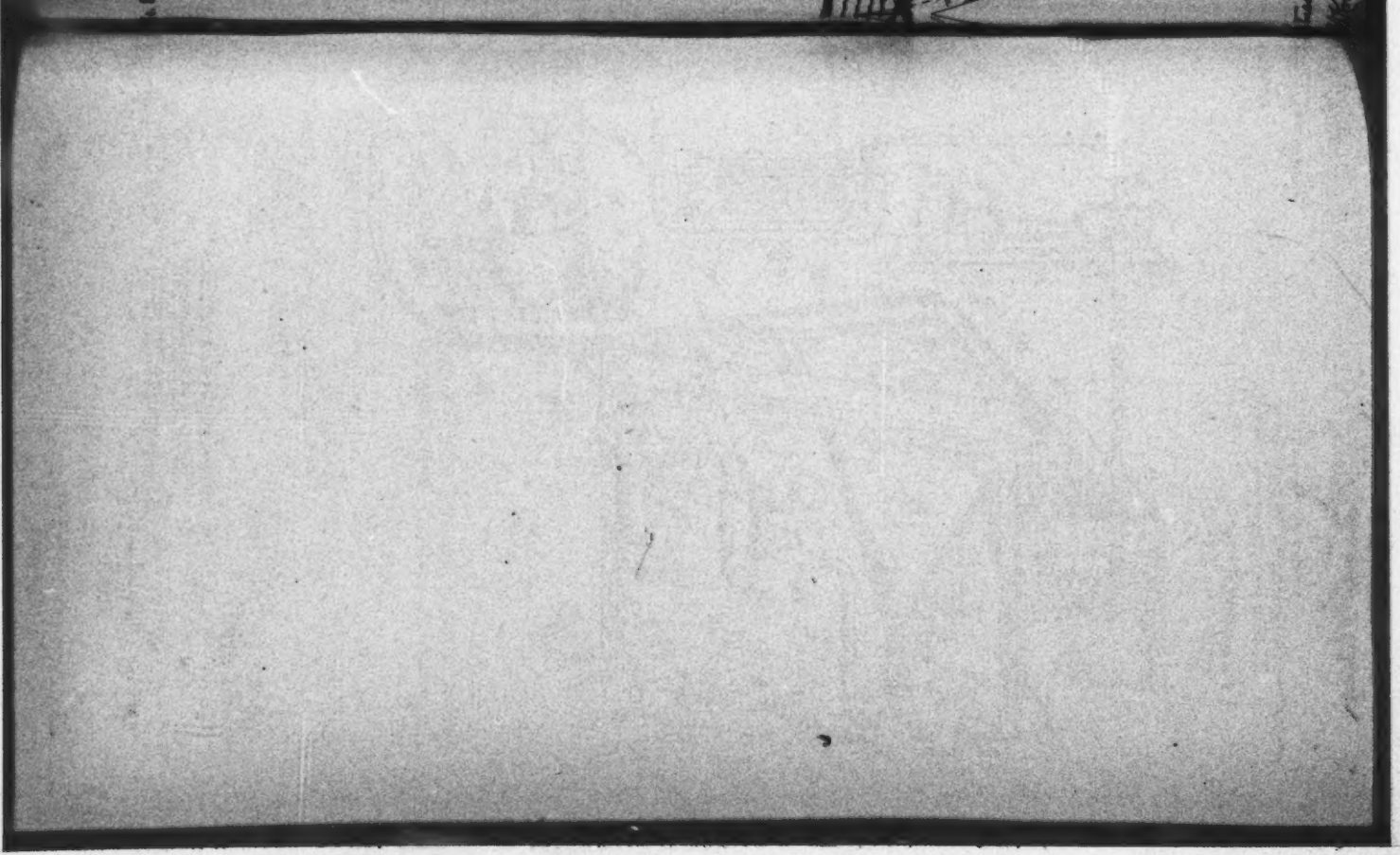


Fig. 1.

Witnesses
M. Wynkoop
B. Hayes.

Inventors
Henry Livingstone Sulman,
Hugh Fortesque Kirkpatrick-Picard and
John Ballot.
by Knight Bros



No. 13
MINER
Separation, Ltd. et al.
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HYDE
Page 945

835,120. PATENTED NOV. 6, 1906.

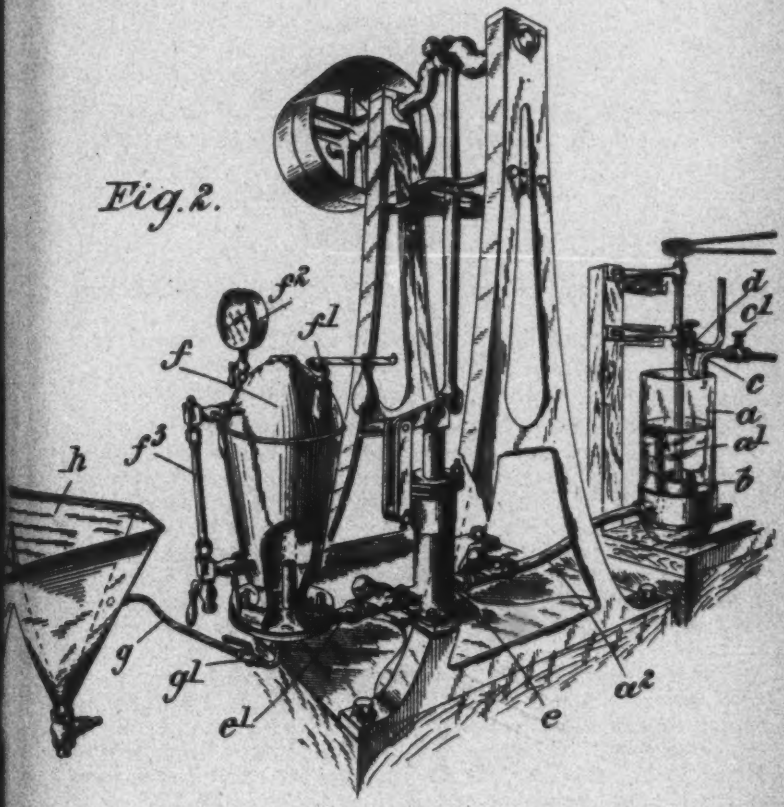
H. L. SULMAN, H. F. KIRKPATRICK-PICARD & J. BALLOT.

ORE CONCENTRATION.

APPLICATION FILED MAY 29, 1905.

2 SHEETS—SHEET 2.

Fig. 2.



Inventors
Henry L. Sulman
Hugh F. Kirkpatrick-Picard
John Ballot
by Wright Bros

Witnesses
Wright

943 [COMPLAINANTS' EXHIBIT DRAWINGS AND SPECIFICATION OF LETTERS PATENT No. 835,120, ISSUED TO HENRY LIVINGSTONE SULMAN ET AL.]

(Here follow diagrams marked pp. 944 and 945.)

946 United States Patent Office.

HENRY LIVINGSTONE SULMAN, HUGH FITZALIS KIRKPATRICK-PICARD, and JOHN BALLOT, of London, England.

Ore Concentration.

No. 835,120.

Specification of Letters Patent. Patented Nov. 6, 1906.

Application Filed May 29, 1905. Serial No. 262,889.

To all whom it may concern:

Be it known that we, Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard, and John Ballot, subjects of the King of England, residing in London, England, have invented certain new and useful Improvements in Ore Concentration, of which the following is a specification.

This invention relates to improvements in the concentration of ores, the object being to separate metalliferous matter, graphite, and the like from gangue by means of oils, fatty acids, or other substances which have a preferential affinity for metalliferous matter over gangue.

In the process described in the previous United States patent, No. 777,273, granted to A. E. Cattermole, an amount of oil varying from four per cent. to six per cent of the weight of metalliferous matter present is agitated with an ore pulp, so as to form granules which can be separated from the gangue. In the previous United States patent, No. 777,274, granted to A. E. Cattermole and others, a similar method of separation is employed, oleic acid being produced in situ in the ore pulp.

We have found that if the proportion of oily substance be considerably reduced—say to a fraction of one per cent. on the ore—granulation ceases to take place, and after vigorous agitation there is a tendency for a part of the oil-coated metalliferous matter to rise to the surface of the pulp in the form of a froth or scum. This tendency is dependent on a number of factors. Thus the water in which the oiling is effected is preferably slightly acidified by adding, say, a

fraction of one per cent. up to one per cent. of sulphuric acid or other mineral acid or acid salt, the effect of this acidity being to prevent gangue from being coated with oily substance, or, in other words, to render the selective action of the oil more marked; but it is to be understood that the object of using acid in the pulp according to this invention is not to bring about the generation of gas for the purpose of flotation thereby, and the proportion of acid used is insufficient to cause chemical action on the metalliferous minerals present. Again, we have discovered that the tendency for the oily substance to disseminate through the pulp and the rapidity with which the metalliferous matter becomes coated is increased if the pulp is warmed. The formation of froth is assisted by the fine pulverization of the ore, and we find that slime mineral most readily generates scum and rises to the surface, while larger particles have less tendency to be included in the froth. The proportion of mineral which floats in the form of froth varies considerably with different ores and with different oily substances, and before utilizing the facts above mentioned in the concentration of any particular ore a simple preliminary test is necessary to determine which oily substance yields the proportion of froth or scum desired.

The following is an example of the application of this invention to the concentration of a particular ore. An ore containing ferruginous blende, galena, and gangue consisting of quartz, rhodonite, and garnet is finely powdered and mixed with water containing a fraction of one per cent. or up to one per cent. of a mineral acid or acid salt, conveniently sulfuric acid or mine or other waters containing ferric sulfate. To this is added a very small proportion of oleic acid, (say from 0.02 per cent to 0.5 per cent on the weight of ore.) The mixture is warmed, say, to 30° to 40° centigrade and is briskly agitated in a cone mixer or the like, as in the processes previously cited, for about two and one-half to ten minutes, until the oleic acid has been brought into efficient contact with all the mineral particles in the pulp.

When agitation is stopped, a large proportion of the mineral present rises to the surface in the form of a froth or scum which has derived its power of flotation mainly from the inclusion of air-bubbles introduced into the mass by the agitation, such bubbles or air-films adhering only to the mineral particles which are coated with oleic acid. The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1 per cent. of the ore; but this proportion has been found suitable and economical.

If the ore were crushed to ninety mesh to the linear inch, (half of which ore will pass through one hundred and fifty mesh sieve,) the froth may contain about seventy per cent. to eighty per cent. of the metalliferous matter present in the ore. This froth is removed from the pulp by spitzkast, upcast, skimming, draining, or otherwise. After subsidence the oil-coated metalliferous matter removed as froth is separated from any liquid which may have accompanied it and treated with a dilute solution of caustic alkali, which removes the oleic acid in the form of a solution of soap.

947

If desired, the oleic acid used in the first instance may be produced in situ in the pulp by decomposing a dilute soap solution with mineral acid, as described in the previous patent, No. 777,274, cited above. The oleic acid or other fatty acid forming the coating on the metalliferous matter which produces the froth may give rise to insoluble soaps on the surface of the metalliferous matter if soluble lime, iron, or other salts are present in small quantity during the production or on the breaking down of the froth with alkali. Such insoluble soaps are difficult to remove and are capable of adhering to air and causing flotation, much the same as the fatty acids do.

The metalliferous matter which did not form part of the froth (generally the larger particles) remains in admixture with the gangue in the pulp. To recover this, the pulp is distributed in a thin layer on a shaking-table, convex bubble, or the like, whereon the mineral is exposed to a free-air surface, which exposure may be increased by the application of air-blast or air-jets or the like and thereafter brought onto the edge or surface of liquid, whereby the metalliferous matter floats and is separated from the gangue, which sinks, as described in the specification of our previous United States application Serial No. 246,637, filed February 20, 1905.

The proportion of mineral recovered in the froth and that recovered by table flotation may be considerably varied; but, generally speaking, the froth will separate the slime mineral while the larger particles are recovered by the latter method.

In the accompanying drawings, Figure 1 is a diagram in perspective illustrating one form of apparatus suitable for carrying this invention into practice, and Fig. 2 represents in perspective an apparatus for carrying out a secondary step in the process.

Referring to Fig. 1, a mixing vessel A (of which there may be any number in series) is provided with a rotatable stirrer B. Crushed ore is fed from a hopper C into the vessel by a band D. A pipe E, controlled by a tap E′, delivers circuit-water to the vessel, and oleic acid or other oil is introduced through the pipe F and tap F′. The outer cock G from the vessel A communicates through a swan-neck pipe H with the froth separating apparatus. In passing from the frothing apparatus A to the spitzkasten (say between O and K) the pulp may, if desired, be run in a thin layer over a smooth slightly-inclined plane.

The froth-separating apparatus comprises several (say three) pointed boxes J' J^2 J^3, which open at the top into a horizontal channel consisting of side walls K. The channel has a narrow inlet K′ and spreads out to a wide outlet K^2. The pointed boxes J' J^2 J^3 have fullway-cocks L' L^2 L^3 at the bottom, leading to swan-neck discharge-pipes M' M^2 M^3. An upcurrent of water may be led in at the bottom of each box through a tap N' N^2 N^3.

The boxes are all filled with circuit-water. The pulp from the vessel A is distributed horizontally from the flat trough O through the inlet K′. The heavy sands and coarser particles of mineral sink into the first box J′, from which they are led to a shaking-table, convex buddle, or the like, to be treated as above described. The middlings or medium sands fall into the box J^2, and if they contain any mineral may be removed for further treatment by agitation. The

upcurrent of water from the taps N′ N² prevents the deposition of any slime in these boxes. The fine sands or gangue slimes settle in the last box J², from which they are discharged to waste or further treatment.

The slime mineral in the form of froth or scum floats from the liquid and is carried by the stream over the outlet K² into a launder P and thence to a filter Q, where the metalliferous matter is removed from the circuit-water, which is returned to the vessel A by a pump R. The circuit-water may be brought to the proper temperature by passing it through a heater S, having a burner S′, before admitting the water to the vessel A.

An alternative method for the recovery of any sunk oiled metalliferous matter which may be deposited in the second and third spitzkasten is as follows: The products suspended in circuit liquor are removed from the spitzkasten and placed in a vessel in which they are submitted to an additional pressure of air or other gas of from, say, one to two atmospheres or over. On relief of such pressure the bubbles of air or other gas so generated throughout the mass at once sweep to the surface thereof all the metalliferous matter in the form of a froth which can be separated as before. This idea is not claimed broadly in this case, but forms the subject-matter of an application filed by us on January 9, 1906, Serial No. 295,326.

Referring to Fig. 2, a mixing vessel *a* (of which there may be several in series) is provided with a rotatable stirrer *b*. Crushed ore or similar finely-divided mineral is fed into the vessel *a*. A pipe *c*, controlled by a tap *c′*, delivers circuit-water to the vessel, and in cases where oil is used the oil is introduced through the pipe *d* in quantity sufficient to produce a thin coating of oil on these mineral particles for which oil has an affinity.

The pulp mixed with oil escapes over the lip of the dis-
948 charge-conduit *a′* and passes through the pipe *a²* to a pump *e*. Hence the pulp is pumped through discharge-pipe *e′* into the closed chamber *f*, which is constructed to withstand a considerable internal pressure and is provided with a safety-valve *f′*, the pressure-gage *f²*, and a gage-glass *f³* to indicate the level of the pulp in the chamber. An outlet-pipe *g* having a cock *g′* leads to a series of spitzkasten *h*, filled with circuit-water.

The operation is as follows: The cock *g′* is closed. Pulp is pumped into the chamber *f*, which contains air or other gas, and the pumping is continued until the pressure in the chamber rises to, say, fifty to one hundred pounds per square inch. The pressure is sufficient to cause the air or other gas to be dissolved to a considerable extent in the pulp. After the lapse of a few minutes for the due solution of the compressed air or a portion of it by the pulp or the liquid the cock *g′* is opened and the pulp is discharged into the open spitzkasten *h*, where the liquid is of course under atmospheric pressure. The pulp *e* may be stopped during this discharge. The whole of the mineral to which air bubbles are attached—say the oiled mineral—at once rises to the surface as a coherent scum or froth. A surface current of water is maintained in the spitzkasten, and the floating material is thus removed and separated from the gangue, which remains sunk or suspended in the liquid.

The nature and arrangement of the apparatus used may be varied without departing from this invention.

What we claim as our invention, and desire to secure by Letters Patent, is—

1. The herein-described process of concentrating ores which consists in mixing the powdered ore with water, adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter, (amounting to a fraction of one per cent. on the ore), agitating the mixture until the oil-coated mineral matter forms into a froth, and separating the froth from the remainder by flotation.

2. The herein-described process of concentrating ores which consists in mixing the powdered ore with slightly-acidified water, adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter (amounting to a fraction of one per cent. on the ore), agitating the mixture until the oil-coated mineral matter forms into a froth and separating the froth from the remainder by flotation.

3. The herein-described process of concentrating ores which consists in mixing the powdered ore with slightly-acidified water, adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter (amounting to a fraction of one per cent. on the ore), warming the mixture, agitating the mixture until the oil-coated mineral matter forms into a froth and separating the froth from the remainder by flotation.

4. The herein-described process of concentrating ores which consists in finely powdering the ore, mixing it with slightly-acidified water, adding a small proportion of an oily substance having a preferential affinity for metalliferous matter (amounting to a fraction of one per cent. on the ore), warming the mixture, agitating the mixture until the oil-coated mineral matter forms into a froth, separating the froth from the remainder by flotation, and removing the oily coating from the mineral.

5. The herein-described process of concentrating ores which consists in mixing the powdered ore with water, adding a small proportion of oleic acid amounting to 0.02-0.5 per cent. on the ore, agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, and separating the froth from the remainder by flotation.

6. The herein-described process of concentrating ores which consists in mixing the powdered ore with water containing a fraction of one per cent. of sulfuric acid, adding a small proportion of oleic acid amounting to 0.02-0.5 per cent. on the ore, agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, and separating the froth from the remainder by flotation.

7. The herein-described process of concentrating ores which consists in mixing the powdered ore with water containing a fraction of one per cent. of sulfuric acid, adding a small proportion of oleic acid amounting to 0.02-0.5 per cent. on the ore, warming the mixture to 30°-40° centigrade, agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, and separating the froth from the remainder by flotation.

8. The herein-described process of concentrating ores which consists in finely powdering the ore, mixing it with water containing a

fraction of one per cent. of sulfuric acid, adding sufficient oleic-soap solution to produce oleic acid amounting to 0.02-0.5 per cent. on the ore, warming the mixture to 30°-40° centigrade, agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, separating the froth from the remainder by flotation, filtering off the froth and removing the oleic acid therefrom by treatment with an alkali.

9. The process of concentrating powdered ores which consists in separating the mineral from the gangue by coating the mineral with oil in water containing a small quantity of oil, agitating
949 & 950 the mixture to form a froth, and separating the froth.

10. The process of concentrating powdered ores, which consists in separating the mineral from the gangue by coating the mineral with oil in water containing a small quantity of oil, warming the mixture, agitating the mixture to form a froth, and separating the froth.

11. The process of concentrating powdered ores, which consists in separating the mineral from the gangue by coating the mineral with oil in water containing a small quantity of oil, and a quantity of acid insufficient to cause chemical action on the metalliferous minerals present, agitating the mixture to form a froth, and separating the froth.

12. The process of concentrating powdered ore which consists in separating the minerals from gangue by coating the minerals with oil in water containing a fraction of one per cent. of oil on the ore, agitating the mixture to cause the oil-coated mineral to form a froth, and separating the froth from the remainder of the mixture.

13. The herein-described process of concentrating ores which consists in finely powdering the ore, mixing it with water containing less than one per cent. of sulfuric acid, adding sufficient oleic-soap solution to produce oleic acid amounting to 0.02-0.5 per cent. on the ore, warming the mixture to 30°-40° centigrade, agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth with the finer mineral, distributing the mixture on the surface of a current of water running over columns of water, so that the coarser minerals and sands, the finer sands and the gangue slimes successively deposit out while the froth is floated away by the current, filtering off the froth and removing the oleic acid therefrom by treatment with an alkali and separating the coarser mineral from the sands by exposing them alternately to air and water.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

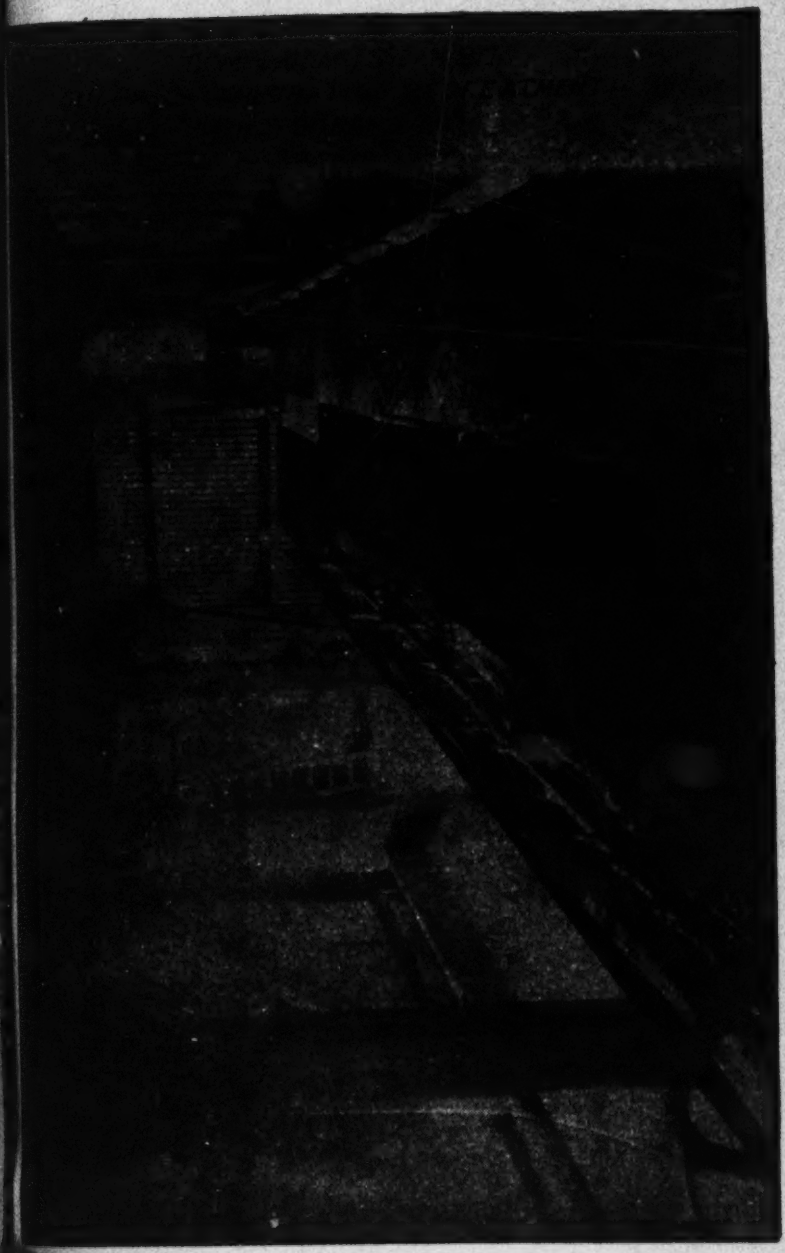
HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK-PICARD.
JOHN BALLOT.

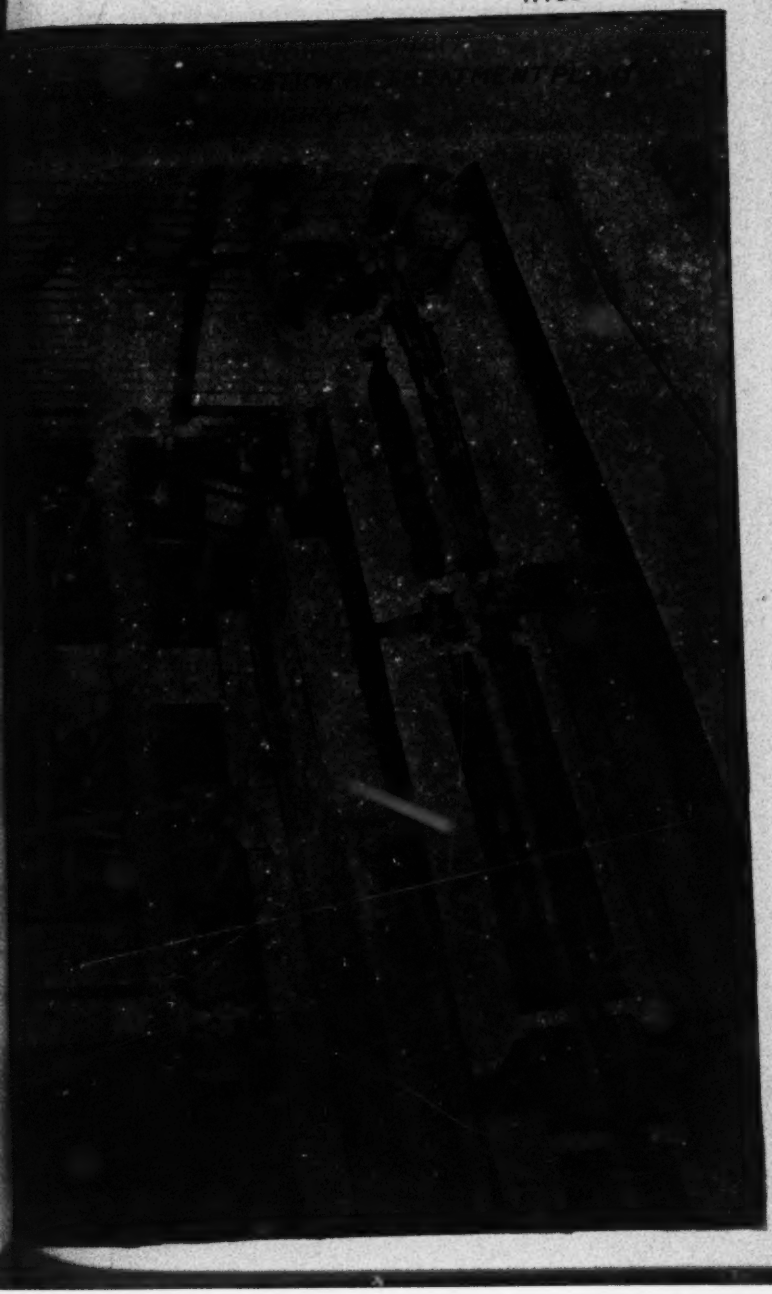
Witnesses:
GEO. J. B. FRANKLIN.
T. J. OSMAN.

(Here follow diagrams marked pp. 951, 952, 953, 954, 955, and 956.)

COMPLAINANTS' EXHIBIT
PHOTOGRAPH AUSTRALIAN CATTERMOLE PLANT

No. 259
MINERALS
Separation, ltd. et al. } Page 952
v.
HYDE.





Complainants' Exhibit-Table of Sulphide Corporation Op

...ABLE OF MATERIAL TREATED AND TONNAGE OF ZINC LEAD SILVER CONCENTRATES OBTAINED BY ...ULPHIDE CORPORATION LD. WITH MINERALS SEPARATION AGITATION FROTH PROCESS –

Period	Material	Feed Tonnage		Concentrates Produced Tons		Total Value £	£
						{Calculated on average Price of Spelter for year}	
Old Tailings Plant							
...ending 30 June 1906	Tailings	23,709		8,013		28,174	
" 30 June 1907	do	65,705		20,621		75,378	
30 June 1908	do	46,394	135,808	16,513	45,147	40,240	143,792
Minerals Separation Ltd Tailings Plant							
...ending 30 June 1908	Tailings	34,506		12,529		31,988	
" 30 June 1909	do	40,684	75,190	14,464	26,993	34,994	66,982
New Mill Zinc Section							
...ending 30 June 1907	By products from Pb section	28,275		6,894		12,817	
" 30 June 1908	do	157,148		34,842		106,799	

tions with Agitation Froth Process

"	30 June 1909	do	157,907		[illegible]		[illegible]	
		By products from Pb section	179,997					
"	30 June 1910	Tailings from annex	47,129		88,767		218,598	
		By products from Pb section	183,322					
"	30 June 1911	Tailings from annex	2,748		71,660		177,447	
		By products from Pb section	180,308					
"	30 June 1912	Dump Slimes	3,665		69,826		263,034	
		Old Tailings	457					
				940,980		359,974		917,213
		Total		1,151,978		432,114		£ 1,127,987
Joint Slimes Plant								
ending	30 June 1908	Slimes	4382		(Zn Pb) 1,738 (Zn) 131 (Pb) 43			
"	30 June 1909	do	2,179		(Zn Pb) 1,109			
"	30 June 1910	do	18,395	24,956	(Zn Pb) 10,164	13,185		26,166
		Total		1,176,934		445,299		£ 1,154,353

(No Model.)

E. R. GABBETT.

APPARATUS FOR MIXING LIQUIDS.

No. 444,345. Patented Jan. 6, 1891.

Fig. 1.

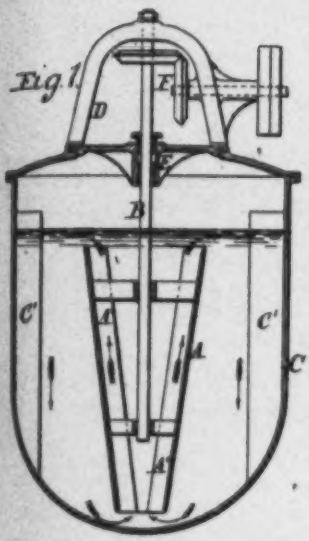


Fig. 9.

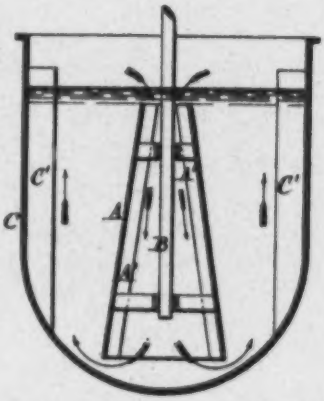


Fig. 2.

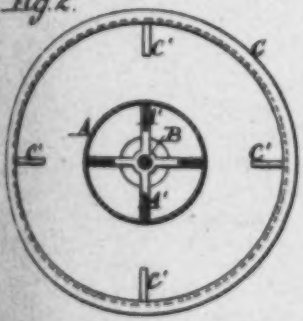


Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Witnesses:
Edmund T. Gabbett
Inventor:

957 [COMPLAINANTS' EXHIBIT DRAWINGS AND SPECIFICATION OF LETTERS PATENT No. 444,345, PATENTED JANUARY 6, 1891, TO EDMOND R. GABBETT.]

(Here follows diagram marked p. 958.)

959 United States Patent Office.

EDMOND R. GABBETT, of Old Charlton, Assignor of One-half to SAMUEL BAGSTER BOULTON, THOMAS BURT HAYWOOD, and HAROLD EDWIN BOULTON, all of London, England.

Apparatus for Mixing Liquids.

Specification Forming Part of Letters Patent No. 444,345, Dated January 6, 1891.

Application Filed July 23, 1890. Serial No. 359,670. (No Model.) Patented in England January 16, 1889, No. 840; in Belgium August 17, 1889, No. 87,411, and in France August 12, 1889, No. 200,153.

To all whom it may concern:

Be it known that, Edmond Rich Gabbett, a citizen of England, residing at Old Charlton, in the county of Kent, England, have invented new and useful Improvements in Apparatus for Mixing, Incorporating, or Effecting the Circulation of Liquids and Semi-Liquids in Vessels, (for which patents have been obtained in Great Britain dated January 16, 1889, No. 840; in Belgium dated August 17, 1899, No. 87,411, and in France dated August 12, 1889, No. 200,153,) of which the following is a specification.

According to this invention I effect the mixing or incorporation of liquids or semi-liquids or the circulation of a liquid within a caldron or tank by the action of centrifugal force upon part of such liquid or liquids in such manner that a body of liquid is thereby continuously withdrawn from the bottom and delivered at the top, or vice versa, thus producing a continuously ascending or descending column of fluid within the apparatus and a corresponding movement in the contrary direction in the body of liquid outside the apparatus. By thus effecting the mixing or circulation of the liquid entirely by centrifugal action, I avoid in a great measure the loss of power due to the friction of mechanical devices moving in the liquid, such as occur in apparatus with helical propelling-blades and the like, heretofore employed.

The apparatus may be constructed in various ways for operating according to my invention. Thus, according to one arrangement I employ a shell of a conical, conoidal, paraboloidal, hemispherical, or trumpet-mouthed shape, fitted, if necessary, with internal ribs and immersed in a vertical position in the liquid, and having both its upper and lower ends open, the ends of larger diameter being situated at top if the circulation is to be in an upward direction through it and at bottom if a downward circulation is required. The shell is fixed by suitable arms to a central strap carried in bearings above the caldron or vat, so that when more or less rapid rotary motion is imparted to it, and consequently to the body of liquid situated within it, the centrifugal force will act in the well-known manner upon such body of liquid, causing it to rise up on the inner wall of the shell and to flow over the upper edge, then into the body of liquid surrounding it, while at the same time fresh liquid will enter the lower end of the shell to replace that which is ejected at top.

The invention is applied in the manufacture of tar products, in sugar-refining, chemical works, distilleries, soap-works, treating ore for the extraction of gold, and for all purposes where liquids and solids require to be brought into intimate contact, or where a constant circulation of liquids is required.

The invention is illustrated by the accompanying drawings, in which—

Figure 1 shows a vertical section of one form of the above-described apparatus, and Fig. 2 shows a plan. Figs. 3 to 8 show modified forms of the shell. Fig. 9 shows an inverted arrangement thereof.

A is a conical shell, having internal ribs A^2 and mounted on a shaft B, by which it is suspended within the vessel or tank C, containing the liquid to be acted upon, the shaft being carried at its upper end by a bracket D and guided by a bush or stuffing-box E on the cover of the vessel C. Assuming this vessel to be charged with liquid to the level indicated and the shell A to be rotated by suitable gearing, such as indicated at F, then the body of liquid within the shell being carried round with the same by means of the ribs A′ the centrifugal force will cause the liquid to rise along the inclined inner surface of the shell and to be ejected into the surrounding liquid when arriving at the upper edge thereof, while at the same time the pressure of the surrounding column of liquid in the vessel C will cause fresh quantities of liquid to enter the lower end of the shell A to make good the quantity discharged at the top. Thus a continuous circulation and consequent mixing of the liquid will be effected, as indicated by the arrows.

960

To prevent the carrying round of the body of liquid in the vessel C by its frictional contact with the outer surface of the shell A the vessel may be provided with projecting ribs C′, as shown. This is, however, not absolutely necessary, and such rotation of the liquid may to some extent be prevented by making the vessel C rectangular instead of circular, as shown, or by arranging a set of two or more revolving shells such as A in the vessel, either grouped round a central driving-shaft or arranged in a row; also,

instead of rotating the shell or shells A continuously in one and the same direction they may have their direction of rotation reversed after any desired intervals of time. This might be effected by applying two driving-pulleys carrying, respectively, an open and a crossed strap, which are shifted alternately onto a loose pulley, as is well understood. The circulation of the liquid can also be made to take place in the contrary direction to that described by inverting the position of the shell A, so that the centrifugal action will cause the liquid within it to travel in a downward direction, as shown at Fig. 9. The shell A may also, if desired, have an oscillating motion imparted to it, so as to move continuously or intermittently with its lower end to different parts of the vessel C, and thus cause the liquid to be drawn consecutively from such different parts. This might be effected by connecting the lower part of the shaft B, carrying the shell, to the upper part running in fixed bearings by a universal joint and imparting the described motion to and fro thereto by a crank, cam, or eccentric, and connecting-rod or by other suitable means. The shell A may be made to extend above the level of the liquid instead of being entirely immersed, as indicated.

Figs. 3 to 8 show diagram sections of various other forms which may be adopted for the revolving shell. Fig. 3 shows a paraboloidal shape; Fig. 4, a construction with hemispherical lower part and cylindrical upper part, the centrifugal action which drives the fluid upward being confined to the lower part. Fig. 5 shows an arrangement in which there are two or more concentric shells, on each of which a body of liquid will be made to ascend by centrifugal action, or there may be only two concentric shells, as at Fig. 6, forming a narrow annular space in which the liquid ascends, there being no opening in the inner shell. If the shell has its upper end immersed to a considerable extent below the liquid level the arrangement shown at Fig. 7 may be adopted, in which the top of the shell A is covered by a shield A^2, leaving a narrow annular orifice at *a* for the issue of the liquid. By this means the pressure of the column of liquid which would otherwise exist in the center of the shell is prevented from interfering with the centrifugal action. Fig. 8 shows a construction in which the lower part of the shell is made cylindrical, while the upper part is made trumpet-mouthed, the centrifugal action being in this case confined to the upper part, or the entire shell might be made of a trumpet-mouth shape.

If found advantageous to lessen the weight or load on the bearings of the shaft by which the shell is revolved, this can be effected by having an air-tight chamber connected to the shell or shaft. Thus, for instance, the shield A^2, (shown in Fig. 7,) being made hollow, will by its flotation partly carry the weight of the shell, &c., or in that of Fig. 6 if the inner vessel is covered and rendered air-tight the same purpose will be attained.

Although it is preferred to impart the necessary rotary motion to the shell by gearing, as described, yet it will be evident that other means might be employed, such as a turbine fitted on the shaft of the shell and driven by steam or other fluid.

The above-described invention is applicable with particular ad-

vantage in cases where the material to be acted upon requires to be maintained at a comparatively high temperature in order to maintain it in a liquid condition, as in such cases the employment of an ordinary circulating-pump within the vessel or caldron would be subject to considerable difficulties.

Having thus described the nature of this invention and the best means I know of carrying the same into practical effect, I claim—

1. An apparatus for mixing or circulating liquids, consisting of a closed tank or vessel for containing the liquid, a rotating conically-shaped shell secured to and suspended by a shaft vertically in the liquid and having upper and lower open ends of different diameters, through the interior of which shell the liquid is caused by centrifugal force to flow in one direction, while the liquid exterior of the shell is caused to flow in a reverse direction, and means for rotating the shell and causing such continuous circulation of the liquid within the tank or vessel and through the shell, substantially as described.

2. An apparatus for mixing or circulating liquids, consisting of a tank or vessel for containing the liquid, a rotating conically-shaped shell having a series of internal ribs immersed and suspended by a shaft vertically in the liquid and having upper and lower open ends of different diameters, and means for rotating the shell and causing a continuous circulation of the liquid within the tank and through the shell, substantially as described.

3. An apparatus for mixing or circulating liquids, consisting of a closed tank or caldron having on its internal surface a series of projecting ribs, the rotating conically-shaped shell immersed and suspended by a shaft vertically in the liquid, provided on its internal surface with a series of ribs and having upper and lower open ends of different diameters, and means for rotating the shell and causing a continuous circulation of the liquid within the tank and through the shell, substantially as described.

961 & 962

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 11th day of July, A. D. 1890.

EDMOND R. GABBETT.

Witnesses:

CHAS. D. ABEL.

JNO. P. M. MILLARD.

(No Model.) 4 Sheets—Sheet 1.

C. B. HEBRON.

PROCESS OF CONCENTRATING ORES.

No. 474,829. Patented May 17, 1892.

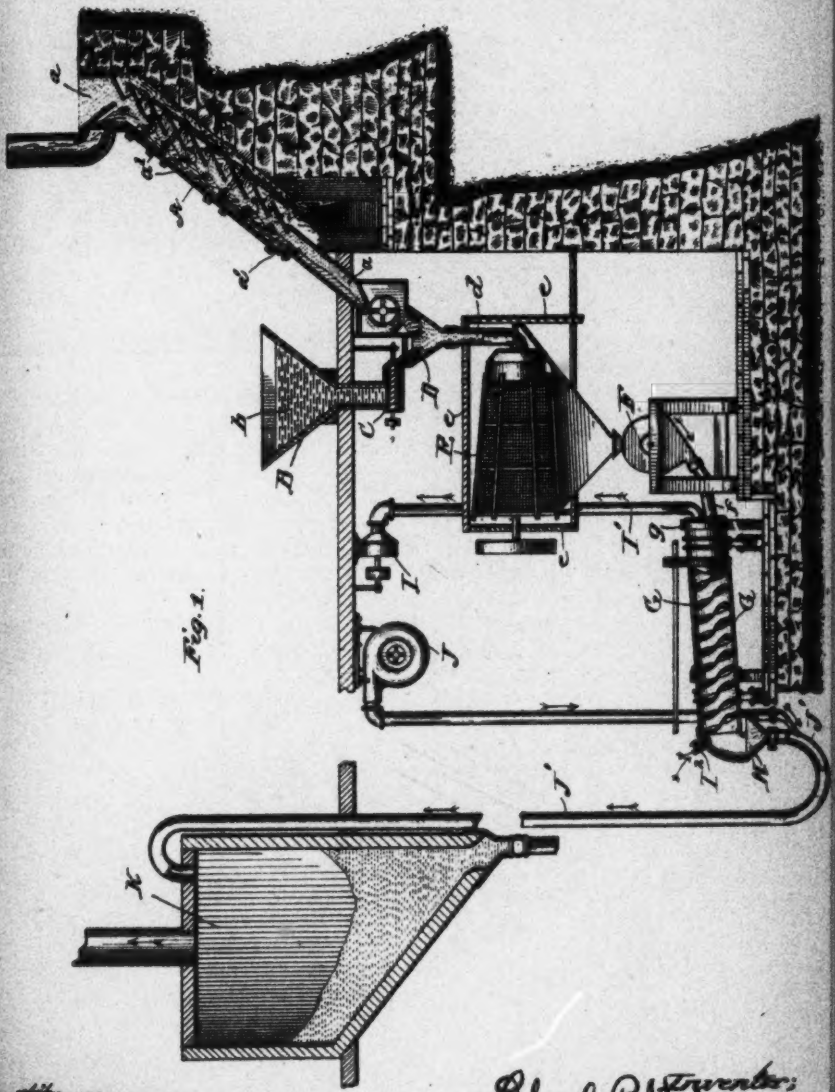
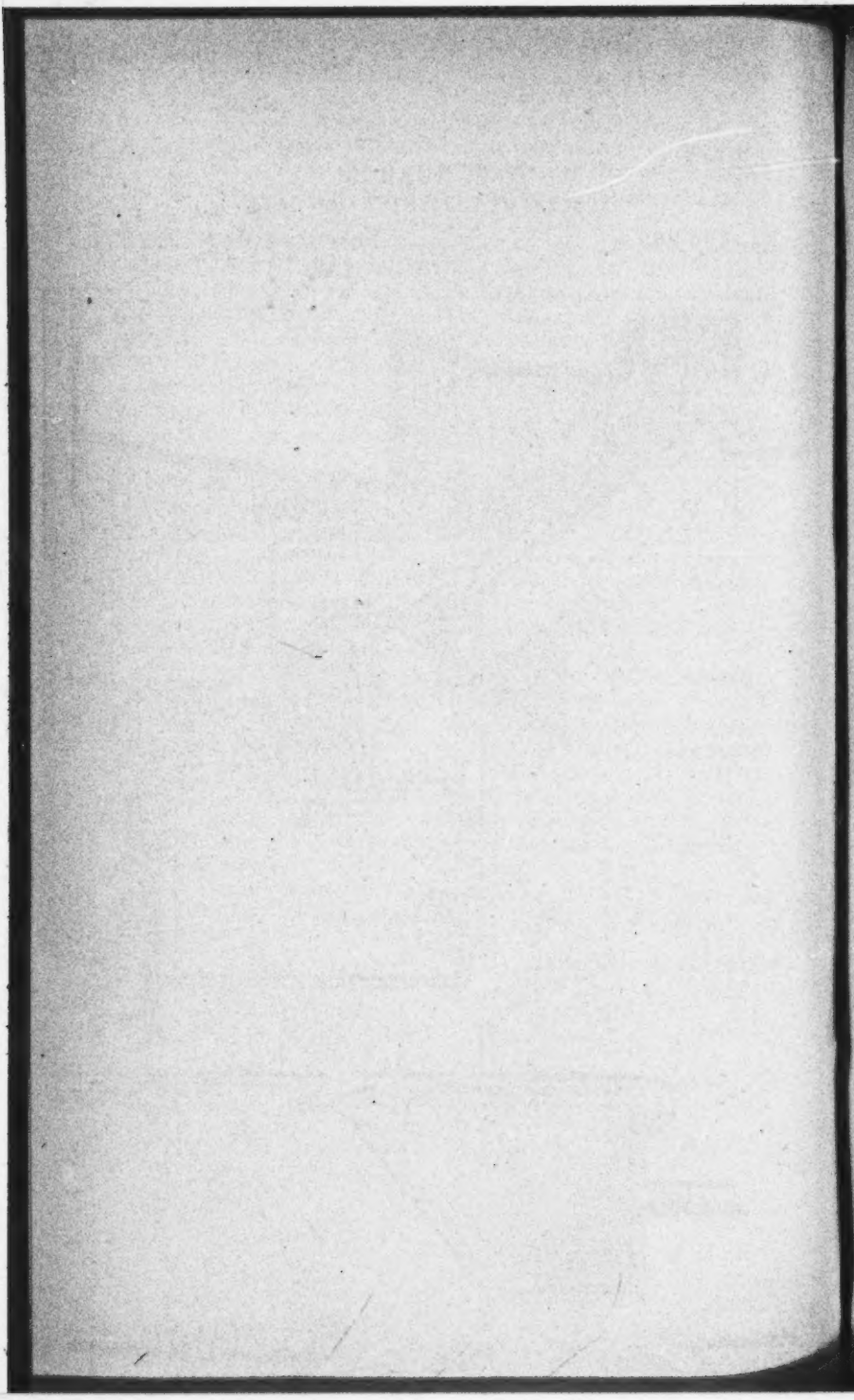


Fig. 1.

Witnesses;
Lester S. Altar

Inventor;
Charles B. Hebron,



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C. B. HEBRON.

PROCESS OF CONCENTRATING ORES.

No. 474,829. Patented May 17, 1892.

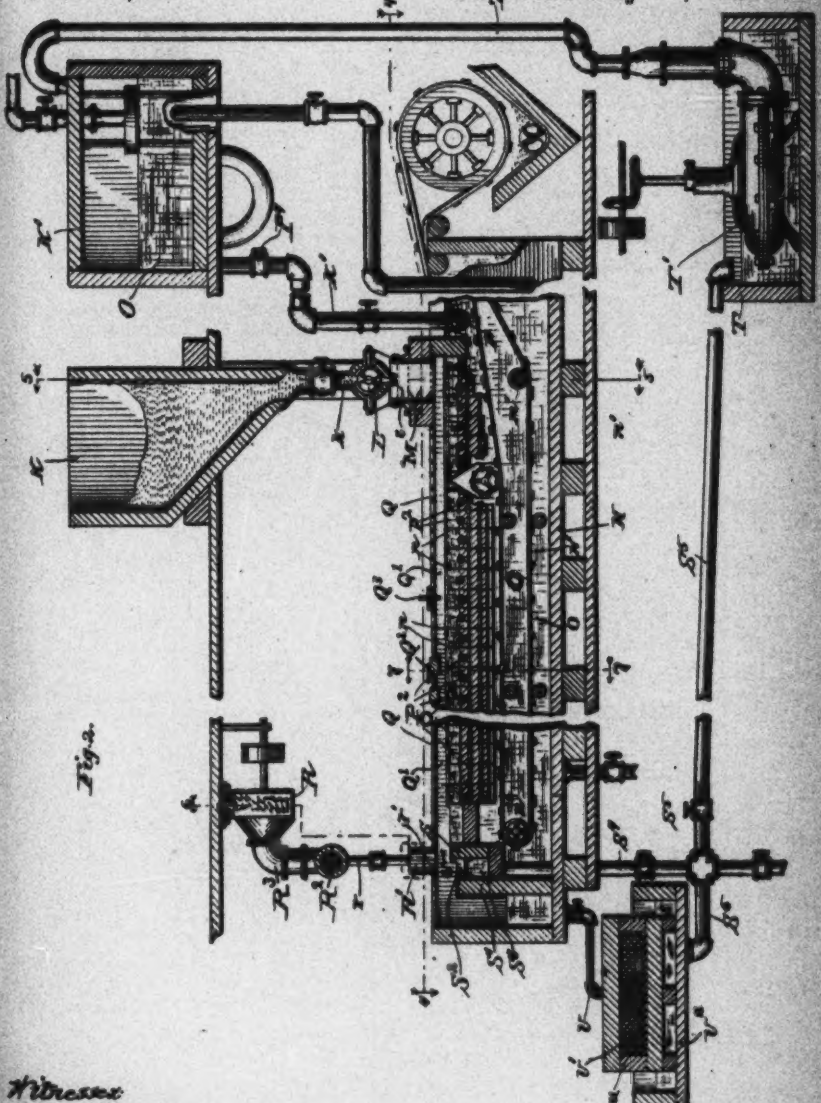


Fig. 2.

Witnesses:
Lute S. Alter
Inventor:

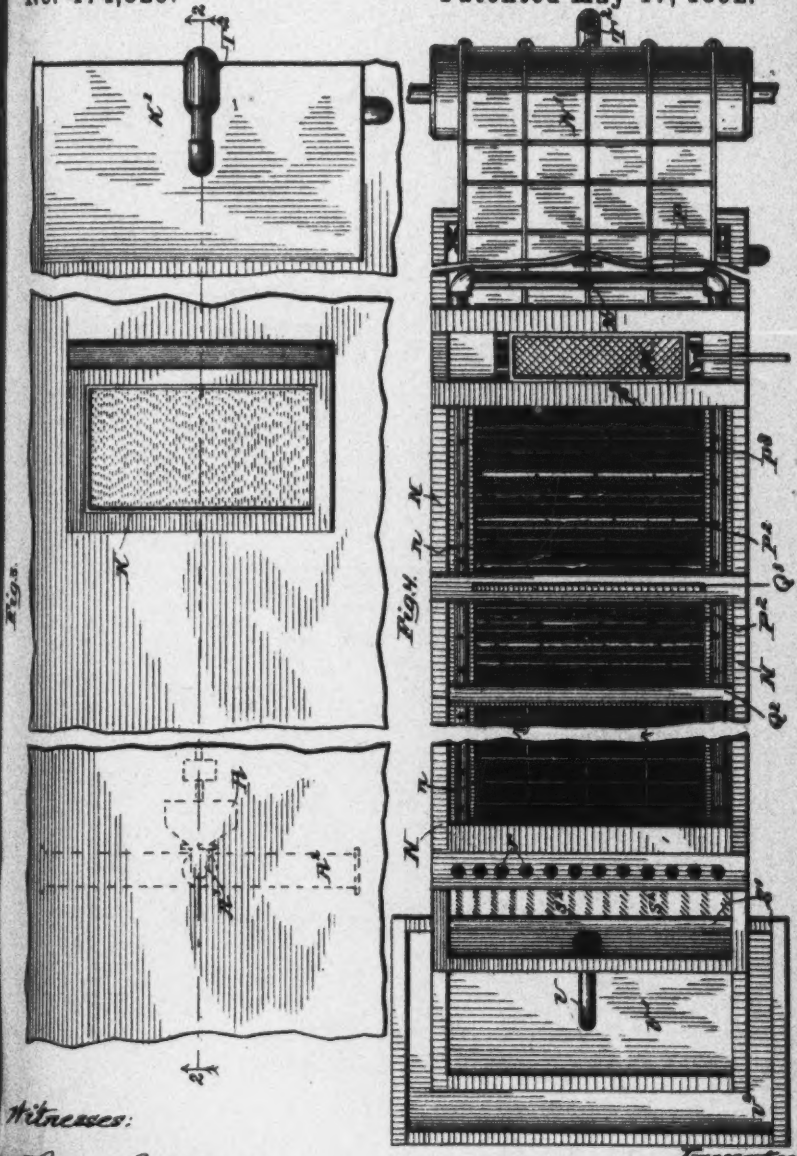
MINERALS
Separation, Ltd. et al.
v.
HYDE.
Page 966

(No Model.) 4 Sheets—Sheet 3.

C. B. HEBRON.

PROCESS OF CONCENTRATING ORES.

No. 474,829. Patented May 17, 1892.



Witnesses:
Lutz & Alter

Inventor;
Charles B. Hebron,

No. 259
MINERALS
Separation, Ltd. et al.
v.
HYDE.
Page 967

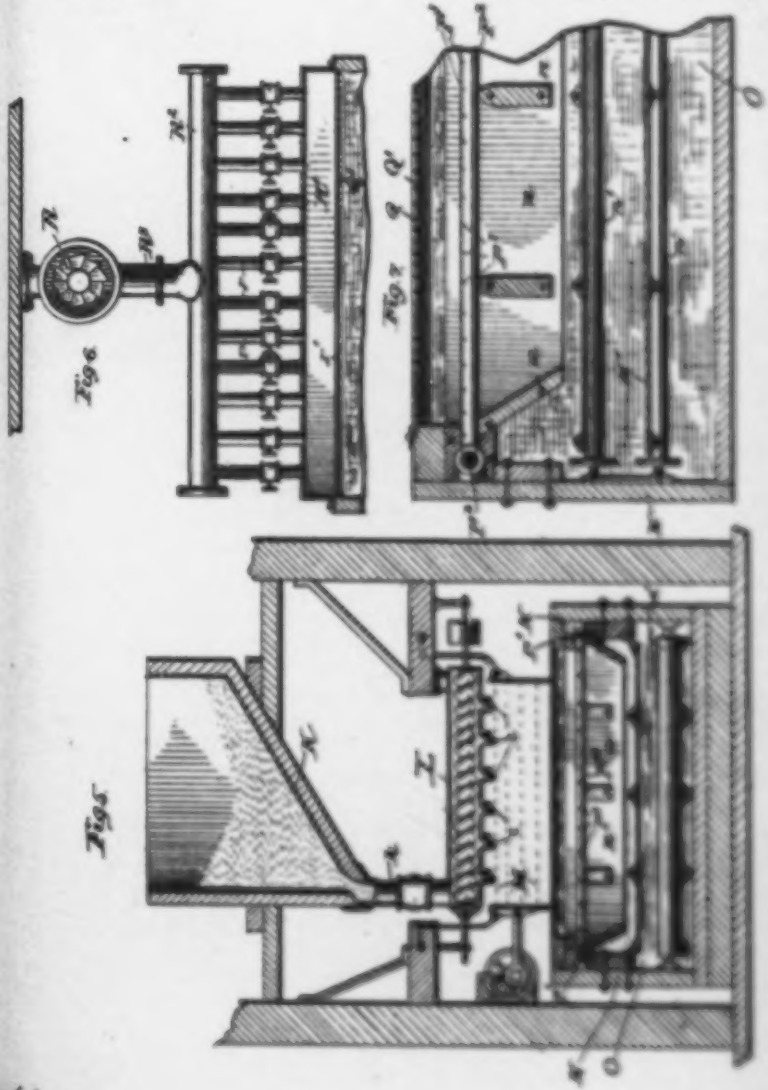
(No Model.)

4 Sheets—Sheet 4.

C. B. HEBRON.

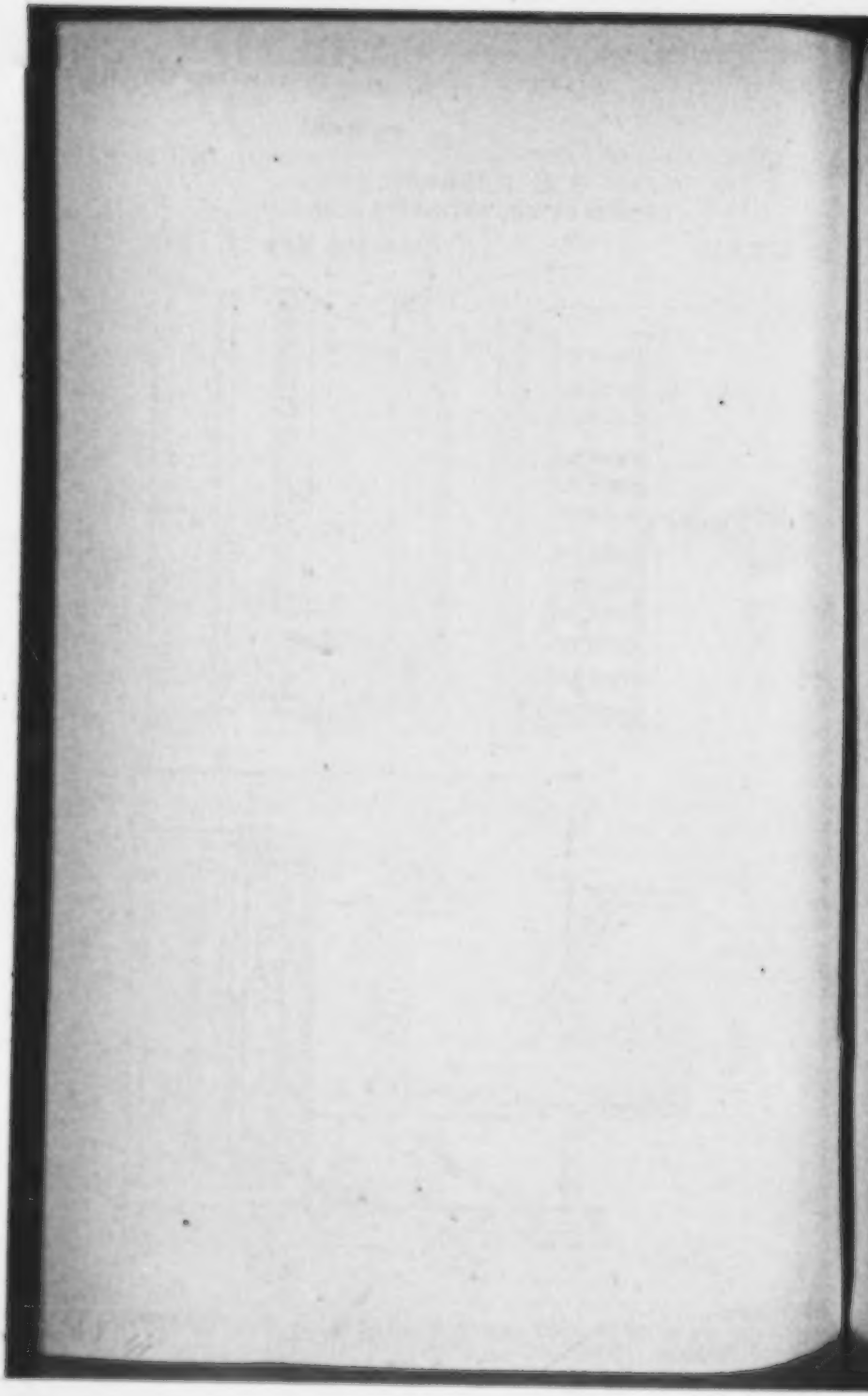
PROCESS OF CONCENTRATING ORES.

No. 474,829. Patented May 17, 1892.



Witnesses
Chas. S. Alter

Inventor,
Charles B. Hebron



963 [COMPLAINANTS' EXHIBIT DRAWINGS AND SPECIFICATION OF LETTERS PATENT No. 474,829, PATENTED MAY 17, 1892, TO C. B. HEBRON.]

(Here follow diagrams marked pp. 964, 965, 966, and 967.)

968 United States Patent Office.

CHARLES B. HEBRON, of Denver, Colorado, Assignor of Five-sevenths to CARRIE J. EVERSON, of Same Place; MAMIE W. HUTCHINSON, of Topeka, Kansas, and CHARLES T. BROWN, of Chicago, Illinois.

Process of Concentrating Ores.

Specification Forming Part of Letters Patent No. 474,829, Dated May 17, 1892.

Application Filed July 22, 1891. Serial No. 400,354. (No Model.)

To all whom it may concern:

Be it known that I, Charles B. Hebron, a citizen of the United States, residing at Denver, in the county of Arapahoe and State of Colorado, have invented certain new and useful Improvements in Processes for the Concentration of Ores; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to practice the same.

My invention relates to a process for the separation or concentration of certain kinds of ores heretofore found particularly intractable and practically impossible to separate; and it consists of certain doings constituting an improvement on the process heretofore invented by Carrie J. Everson and myself jointly, such joint invention being described and claimed in the application for a patent filed by us on the 1st day of September, 1891, Serial No. 404,400, allowed January 9, 1892, and may be considered as founded upon the same principles as is the process described in the application referred to, in conjunction with other principles not therein set forth. The process described in such joint application consists, briefly stated, in first pulverizing the ore to the proper fineness, (which pulverization must in every instance reach the cleavage or disintegration of the ore and may be much finer than that required to reach such cleavage or disintegration in cases where the mineral particles of the ore are in coarse dissemination in the rock, or where free metal is mechanically combined with rock,) after such pulverization applying to the ore while in a dry state a quantity of dry buoyant mate-

rial, with proper pressure and movement, as by rubbing under pressure—say with the use of burrs or equivalent mechanical devices—whereby the buoy stock is forced into the openings or interstices existing between the atoms constituting the porous metallic and mineral particles, or is caused to adhere to the irregular or roughened surface of such metallic and mineral particles and said particles thereby made buoyant, and the ore stock thus prepared being subsequently delivered to or upon the surface of the water in suitable manner to subject the same to flotation thereupon, the buoyant mineral and metal particles remaining as a scum upon the water, while the rock matrix of the ore stock, or, in mining parlance, the "gangue" thereof settles, resulting in separation.

It is to be understood that the foregoing briefly-described process and the herein described and claimed process are based upon the difference in formation between the rock crystals and the mineral and metal particles constituting the ore adapted for treatment by this process, the latter being porous, while the former are crystalline in character and the surface thereof glassy, whereby the buoy stock may be said to attack the disintegrated metallic and mineral particles without affecting the smooth rock crystals, such difference in structure between the mineral and metal particles and the rock crystals being distinctly marked in the class of ores I seek to separate by this process.

My present invention or discovery relates to the preparation of the ore for the presentation thereto of the buoy stock in such manner and by such means that the mineral and metal particles contained in such ore stock are made to receive greater quantities of such buoy stock than has been heretofore possible.

In properly-pulverized ore of the class or kind which this invention relates to the mineral and metal particles, being of the character hereinbefore described, when at about climatic temperature contain and are surrounded by particles of air or other gases, and the presence of such air or other gases retards, hinders, and partially prevents the attachment to and joining with such particles of as large a bulk of buoy stock as is possible when such air or other gases are not present. Further, if the openings, cells, cavities, depressions, or pores contained in and on the mineral and metal particles in the ore are enlarged, (particularly when such enlargement is obtained in connection with the absence of air or other gases in or on such particles,) and at such time the buoy stock is presented thereto and thoroughly pressed therein, the capacity of such particles for containing and mechanically joining with the buoy-stock material is increased.

The object of my invention is to obtain greater buoyancy
969 in the joined mineral and metal particles and buoy stock than has heretofore been obtained, and to attain such object I expel from such mineral and metal particles an appreciable quantity of the air and other gases contained in the openings, cells, cavities, depressions, or pores thereof, or surrounding them at the time of presenting thereto and pressing thereinto the buoy stock by producing as far as practicable a vacuum in the receptacle containing

the ore and the buoy stock and the mechanism effecting the joining of the mineral and metal particles of the ore with the particles of the buoy stock, or, and preferably, by applying heat to the ore, thereby obtaining the desired expulsion of air and other gases prior to the presentation to and pressing of such buoy stock into and upon the mineral and metal particles of the ore, and retaining such heated condition in the ore until such buoy stock is properly brought in contact with the mineral and metal particles thereof and pressed therein and upon, thus producing at the same time an enlargement of the openings, cells, cavities, depressions, or pores contained in and on the mineral and metal particles.

In order to heat the previously-pulverized ore, it is placed in a receptacle, where it is subjected to a dry artificial heat of considerable intensity, but not sufficient to materially volatilize the values thereof.

I have found the following-described mechanical devices used in the herein-stated manner efficient in reducing my invention to practice, to wit: an infusion fire-blast rotary cylindrical furnace, or the equivalent thereof, into which the ore stock is continuously fed at one end and conveyed through the fire-chamber thereof to and discharged at the other end onto a shaking or rotating screen, which is closely housed for the purpose of checking radiation of heat, an automatic conveyer by which the buoy stock is fed in a cold and preferably chilled condition from its storage-receptacle to the same screen on which the heated ore is being fed, whereby the buoy stock and the pulverized ore passing through the meshes of the rapidly-oscillating screens are commingled prior to their delivery therefrom; suitably-adjusted rotary burr-disks between which the ore and buoy stock are delivered from the screen, whereby the buoy stock particles are pressed into and upon the heated mineral and metal particles of the ore; a cooling and aerating device by which the ore stock thus far prepared is cooled and aerated, and an ore-separator.

The amount of buoy stock supplied to the ore is determined by the bulk of metal and mineral contained in the ore. The buoy stock should, I find, be approximately equivalent in bulk to the bulk of such mineral, the ore having prior to the delivery thereof to the oscillating or rotary screen where it is first brought in contact with the buoy stock been heated in the furnace to considerable intensity and in excess of the temperature required to properly expel the air and other gases therefrom and obtain the maximum enlargement of the openings, cells, cavities, depressions, or pores thereof. Provision is thereby made for the partial cooling of the ore, which results from contact with the mineral and metal particles thereof, and pressing thereinto and thereon of the cold or chilled buoy stock particles and from radiation, and such excess must be sufficient to maintain in the ore stock while between the burr-disks the heated condition necessary for preserving the practical expulsion of the air and other gases from the mineral and metal particles, so that the partial vacuumed condition attained in the openings, cells, cavities, depressions, or pores of the mineral and metallic particles shall not be broken until the buoy stock particles have been joined thereto.

To aerate such joined metallic and mineral and buoy-stock particles a blast or current of cold and preferably chilled air is blown through the so-far-prepared ore stock as it falls from the slots in the hopper, into which it is delivered from the burrs, or as it passes through a conveyer before reaching such hopper. This blast of cold or chilled air, in addition to aerating and cooling the nearly-prepared ore stock, can be of sufficient volume and force to convey the ore stock to a receptacle, from which it is taken by an automatic conveyer in proper quantities to supply the working capacity of the separator.

A suitable separator for use in this process consists of a rectangular tank placed in a horizontal position and nearly filled with liquid, the width of which tank is determined by the capacity desired, the depth being sufficient to have contained under the surface of the liquid therein partitions provided for stalling the current of the liquid in the tank below the surface thereof, and for an endless apron-belt movable beneath such partitions with the necessary idlers, pulley-rollers, and supports thereof, on which apron-belt the rock matrix settles, and by the movement of which it is conveyed from the tank to the determined place of deposit therefor. The movement of the apron-belt is toward the head of the tank, and it rises out of the same on an incline at the head, carrying the rock matrix settled thereon out of the tank, and the liquid in the tank is discharged therefrom at the tail thereof, floating the concentrates thereupon. The partitions designed to stall the liquid in the tank extend from one side thereof to the other, and from near the surface of the liquid—that is, from less than one-half inch thereof—to near the endless apron-belt—say within less than one-half inch thereof. The liquid supplied the tank and forming the overflow at the tail thereof is delivered through horizontal pipes extending across the tank between the stalls, the top of such pipes being about one and one-half inches below the top of the stall-partitions, and such pipes being perforated on their upper halves, the liquid which
970 is contained therein under pressure will, as it is forced through the perforations, produce an effervescing condition at and near the surface of the liquid in the tank, such effervescing condition of the liquid tending to loosen the rock matrix from the buoyed values of the ore stock in the surface-fed charge, causing the rock particles to break away from the same at the surface of the liquid and settle through it between the stall-partitions to the moving endless apron-belt. These perforated pipes, through which the liquid is supplied to the tank, extend from a point underneath the feed-screens for about one-fifth to one-third the length of the separator-tank. For the distance between the tail terminus of this series of pipes and the tail of the series of partitions for stalling the liquid all effervescence ceases, allowing the liquid between such partition-stalls to be calm, thereby offering less obstruction to the settling of the more exhausted rock particles which remain suspended in the shallow current above such stall-partitions for a greater time and distance than the coarser particles of the rock matrix, permitting this more exhausted residuum to settle upon the moving endless apron-belt at points nearer the tail of the separator. The prepared

ore stock delivered upon the rapidly-oscillating feed-screens passes through the series of screens and is delivered to the surface of the liquid in the tank in the form of a continuous dust-cloud, and the metallic and mineral values of the ore stock contained therein are separated from the rock matrix, as heretofore described. The longitudinal movement of the floating film or scum containing the values of the ore must be in pace with the supply of ore from the feed, which must be only rapid enough to thinly cover the liquid-surface. A chamber exists between the liquid-surface and the tank-covering, (which should be transparent,) through which a gentle suction air-blast is drawn over the scum longitudinally and exhausted through air-flues rising above the tail end of the separator-tank by means of a suction-fan. This air-blast causes the scum or floating film to move upon the liquid-surface rapidly, thereby increasing the capacity of the separator and admitting of the use of a slow and sluggish surface current above the upper edges of the stall-partitions. This torpid movement of the liquid-current allows the rock particles to settle more easily than if capacity was obtained by a rapid movement of the liquid-surface, which would impart such momentum as to hold the rock particles longer in suspension, and therefore requiring much greater length of tank-surface to obtain a good separation.

The liquid commonly used in the separator-tank is water; but in northern latitudes or in a high altitude, particularly in the winter season, it will be found desirable to use a liquid less subject to freezing than water, and as in this process the produce and the residuum of the pulverized ore stock are severally removed from the separator-tank, leaving the liquid employed therein when delivered at the tail end of the apparatus in condition to be returned to the storage and again used, any liquid of sufficient fluidity whereof the specific gravity is less than the specific gravity of the rock matrix can be employed, provided, of course, the separator-tank and its appurtenances coming in contact with the liquid are constructed of material well adapted to resist the action thereof. Hence common brine (a solution of sodium chloride) is practically available, and other liquids might be used.

Between ore specially adapted for treatment by this process and ore unfit to be treated thereby there is found ore wherein the mineral and metallic particles are so dense and compact in physical structure that the buoyant character necessary for the best results in the separator-tank where water is employed as the liquid is somewhat difficult to obtain, even by the use of buoyant particles joined thereto in the manner hereinbefore described, and in such case it will be found highly desirable that brine or some liquid having greater specific gravity than water be employed as a substitute thereof.

In the drawings accompanying and forming a part of this specification mechanisms are illustrated adapted to perform the several functions demanded thereof in the carrying out of this process, and in such drawings—

Figure 1 is a cross-sectional view of a continuous fire-blast furnace and an elevation of the machinery employed therewith, whereby the pulverized ore is properly prepared, as herein described, and deposited

in the storage-chamber, such storage-chamber being also shown in cross-section in said figure; Fig. 2, a longitudinal sectional view of an ore-separator on line 2 2 of Fig. 3; Fig. 3, a plan view of a liquid storage and pipes thereinto and therefrom and a prepared ore-stock storage, forming appurtenances to such ore-separator; Fig. 4, a longitudinal sectional view on line 4 4 of Fig. 2, viewed in the direction indicated by the arrows, the top of the tank of the ore-separator being transparent and so exposing to view the several parts in the tank of the separator; Fig. 5, a vertical cross-section on line 5 5 of Fig. 2, viewed in the direction of the arrows; Fig. 6, a vertical cross-section on line 6 6, also viewed in the direction indicated by the arrows; Fig. 7, a vertical cross-section of a portion of the device, on an enlarged scale, on lines 7 7 of Fig. 2, viewed in the direction indicated by the arrows.

Similar letters of reference are employed to indicate a part where more than one view thereof is shown.

A is a continuous fire-blast furnace, *a*, the pulverized ore passing through A, and *a'* the fire-blast of such furnace.

B is a storage-receptacle for the material of buoyant char-
971 acter required in this process, which material I prefer shall ordinarily consist of pulverized charcoal.

C is an automatic conveyer, by which the prepared buoy stock is fed from storage-receptacle B to trough D.

E is a rotatory screen, and *e* the housing thereof.

The pulverized and heated ore *a* is delivered from the furnace A, through trough D and pipe *d*, into the rotary screen E, and *b* is the buoyant material contained in storage B, which is also delivered by conveyer C into the trough D, along with the pulverized and heated ore *a*, and passing therewith into the rotary screen E. Rotary burr-disks are contained in the frame F. Such disks being well known in the art, I do not deem it necessary to expose the same to view.

G is a rotary conveyer by which the ore stock delivered thereto from spout *f*, after having passed through the burr-disks, is conveyed to trough H.

I is the fan by which air, preferably cooled or chilled, is drawn through the pipe I' from cock I^2 is the conveyer G, producing a gentle current over the contents of the conveyer from such cock I^2 to the point in the non-rotatable head *g* thereof, where pipe I' is secured.

J is a fan by which a current of air can be forced into the pipe J' and the contents of such pipe be thereby elevated and deposited into the storage-receptacle K, from which they can be delivered to the ore-separator.

The ore-separator which I prefer to use is one wherein liquid is employed as the fluid, through which, by the action of gravity, certain parts of ore stock, as hereinafter explained, will fall and on which other parts of such prepared ore stock will float to the point of delivery therefrom.

K', Fig. 2, is a storage-receptacle for the liquid required in the separator. From storage-receptacle K a pipe *k*, having a suitable valve therein, extends to the conveyer L, from which conveyer the prepared ore stock is dropped through discharge pipes or nipples *l l*

the shaking-screens M M, through which screens such prepared ore stock passes and from which it is delivered upon the surface of the liquid O, contained in the rectangular tank N. From the storage-receptacle K′ a pipe *k′* extends into the tank N, and through such pipe the liquid O passes into such tank.

n n are the partitions provided in the tank N.

N′ is an endless movable apron-belt beneath such partitions, and *n′* are the idlers or pulley-rollers supporting the belt.

P is a horizontal pipe extending laterally across the tank N below the surface of the liquid contained therein.

P′ P′ are horizontal pipes extending longitudinally for a portion of the length of the tank, and P^2 P^2 are horizontal pipes extending laterally underneath the surface of the liquid in the tank.

P^3 P^3 are holes in the pipes P^2 P^2. The liquid passing from the tank K′ through the pipe *k′* extends through the pipes P P′ P^2 and enters the tank through holes P^3 in pipes P^2. The proper pressure under which the liquid passes out of the holes P^3 P^3 can be determined by valve P^4 in pipe *k′*.

Q is the transparent cover of the tank.

Q′ is the chamber extending between the surface of the liquid and the cover.

R is a suction-fan, and *r r* are pipes extending from chamber R′ to horizontal pipe R^2, such horizontal pipe being connected to fan R by pipe R^3. *r′* is a screen interposed between the chamber R′ and the chamber Q′. The movement of the suction-fan R creates the air-blast hereinbefore referred to in the chamber Q′, between the open slide Q^2 and the chamber R′.

Q^3 is a vertical slide extending from the cover Q through the chamber Q′ to near the surface of the liquid O and prevents any blast or current of air above such liquid between such slide Q^3 and the screens M.

S S′ are bridge-walls over which the liquid and the prepared ore stock thereon passes.

S^2 is a screen or perforated plate between the bridge-walls S S′, through which much of the liquid passing over bridge-wall S can flow into the chamber S^3 underneath the screen, and from thence through pipe S^4 to waste or to pipe S^5, through which it flows to receptacle T, from which, by the pump T′, it can be raised through the pipe T^2 into the receptacle K′. The liquid and prepared ore stock thereon, containing the values of the ore passing over the bridge-wall S′, flow through the pipe U into the receptacle U′.

u u are screens in receptacle U′, through which the liquid can flow into the receptacle U^2, from which receptacle it can flow through pipe S^5 to receptacle T. The prepared ore stock remains in the receptacle U′, from which it is taken when desired.

It will be evident to those skilled in the art that liquid employed as a suspensive fluid in the manner described is not the sole way in which suspension in different strata for sufficient time to separate the buoyed mineral and metallic particles from the rock matrix of the ore can be effected, as any of the well-known stratifying mechanical devices can be used as an element of this process for the

purpose of separating the heavier from the lighter particles, a
thereby stratifying the ore stock, and when the ore prepared by th
process is properly subjected to such mechanical devices it will
found that the buoyed mineral and metallic particles will, bei
lighter, obtain the upper strata.

Having thus described my invention, what I claim, and des
to secure by Letters Patent, is—

1. The herein-described process for concentrating o
972 consisting of producing a vacuumed condition in the mine
and metallic particles of properly-pulverized ore, of presenti
to such ore while in such vacuumed condition and by movem
and pressure mechanically joining with the mineral and metall
particles thereof particles of buoyant material, of aerating su
buoyed mineral and metallic particles, and of subjecting such p
pared and aerated ore stock to controllable stratifying agenci
whereby the rock matrix of the ore stock is caused to settle aw
from the buoyed mineral and metallic particles thereof and
thereby separated from such buoyed mineral and metallic particl
substantially as described.

2. The herein-described process for concentrating ore, consisti
of producing by heat a vacuumed and expanded condition in t
mineral and metallic particles of properly-pulverized ore, of pr
senting to such ore while in a heated, vacuumed, and expande
condition and by movement and pressure mechanically joining wi
the mineral and metallic particles thereof particles of buoyan
material, of cooling and aerating such buoyed mineral and metalli
particles, and of subjecting such prepared ore stock to controllabl
stratifying agencies, whereby the rock matrix of the ore stock i
caused to settle away from the buoyed mineral and metallic particl
thereof and is thereby separated from such buoyed mineral an
metallic particles, substantially as described.

3. The herein-described process for concentrating ore, consisti
of producing by heat a vacuumed and expanded condition in th
mineral and metallic particles of the ore, of presenting to such or
while in a heated, vacuumed, and expanded condition and by move
ment and pressure mechanically joining with the mineral an
metallic particles thereof particles of buoyant material, of coolin
and aerating such buoyed mineral and metallic particles, and
presenting such prepared ore stock to the surface of liquid, so th
the buoyed mineral and metallic particles of the ore stock are main
tained upon the surface of such liquid for a greater length of tim
than the rock matrix of the ore stock and thereby for such tim
separated therefrom, substantially as described.

4. The herein-described process for concentrating ore, consisti
of producing by heat a vacuumed and expanded condition in th
mineral and metallic particles of the ore, of presenting to such or
while in a heated, vacuumed, and expanded condition and by move
ment and pressure mechanically joining with the mineral an
metallic particles thereof particles of buoyant material, of cooling
and aerating such buoyed mineral and metallic particles, of obtain
ing a tremulous movement on the surface of a body of liquid b

roducing an effervescing condition therein below and at the surface hereof, and of presenting such prepared ore stock to the tremulous rface of such liquid, so that the buoyed mineral and metallic parcles of the ore stock are maintained upon such surface for a reater length of time than the rock matrix of the ore stock, and hereby for such time separated therefrom, substantially as deribed.

5. The herein-described process for concentrating ore, consisting f producing by heat a vacuum and expanded condition in the minral and metallic particles of the ore, of presenting to such ore while n a heated, vacuum, and expanded condition and by movement and ressure mechanically joining with the mineral and metallic parcles thereof particles of buoyant material, of cooling and aerating uch buoyed mineral and metallic particles, of presenting such prepared ore stock to the surface of liquid so that the buoyed mineral nd metalic particles of the ore stock are maintained upon the surace of such liquid for a greater length of time than the rock matix of the ore stock, and of producing a current of gas moving in elation to the surface of the liquid and in a direction from the lace of presentation of the prepared ore stock to the surface thereof, hereby the buoyant mineral and metallic particles of the ore tock are esparated from the rock matrix thereof for such time, nd particles of the ore stock floating upon the surface of the liquid re moved over and on the surface of such liquid by such current f gas, substantially as described.

6. The herein-described process for concentrating ore, consisting f producing by heat a vacuumed and expanded condition in the ineral and metallic particles of properly-pulverized ore, of preenting to such ore while in a heated, vacuumed, and expanded ondition and by movement and pressure mechanically joining ith the mineral and metallic particles thereof buoyant material, f cooling and aerating such buoyed mineral and metallic parcles, of obtaining a tremulous and wavy movement on the surface f a body or liquid contained in a receptacle having stalling-paritions by producing an effervescing condition in the liquid below nd at its surface and a current of gas moving over and on such rface, and of presenting such prepared ore stock to the surface of he liquid, so that the buoyed mineral and metallic particles of ore re maintained on the surface of such liquid for a greater length f time than the rock matrix of the ore stock, and thereby for such ime separated therefrom and the particles of ore stock floating on he surface of the liquid moved on and over such surface, subtantially as described.

CHARLES B. HEBRON.

Witnesses:
WILLIAM B. ELLIS,
CHARLES T. BROWN.

973 [COMPLAINANTS' EXHIBIT DRAWINGS AND SPECIFICATIO OF LETTERS PATENT No. 575,669, PATENTED JANUAR 19, 1897, ISSUED TO G. ROBSON.

(Here follow diagrams marked pp. 974 and 975.)

976 United States Patent Office.

GEORGE ROBSON, of Dolgelly, England, Assignor to Himself, and SAMUEL CROWDER, of London, England.

Separation of Metals and Metallic Compounds from Ores or Othe Substances.

Specification Forming Part of Letters Patent No. 575,669, dated January 19, 1897.

Application filed July 18, 1894, Serial No. 517,937. (No model.) Patented in England January 8, 1894, No. 427; in Transvaal April 2, 1894, No. 617; in France July 5, 1894, No. 239,819; in Germany November 24, 1894, No. 82,722; in Victoria October 29, 1895, No. 12,628; in New South Wales October 31, 1895, No. 6, 163; in South Australia October 31, 1895, No. 3075, and in New Zealand November 5, 1895, No. 8035.

To all whom it may concern:

Be it known that I, George Robson, a subject of the Queen of Great Britain and Ireland, residing at Llanfachreth, Dolgelly, North Wales, United Kingdom of Great Britain and Ireland, have invented an Improvement in the Separation of Metals and Metallic Compounds from Ores or other Substances, (for which I have obtained Letters Patent in England, No. 427, dated January 8, 1894; in France, No. 239,819, dated July 5, 1894; in Germany, No. 82,722, dated November 24, 1894; in Victoria, No. 12,628, dated October 29, 1895; in New South Wales, No. 6,163, dated October 31, 1895; in South Australia, No. 3,075, dated October 31, 1895; in New Zealand, No. 8,035, dated November 5, 1895, and in Transvaal, No. 617, dated April 2, 1894,) of which the following is a specification.

This invention has for its object to separate and recover, in an economical manner, finely-divided metal and metallic compounds, such as sulfids and metallic oxids present in finely-divided substances, such as crushed ores, slimes, and the refuse matter, such as the tailings, float matter, and the like, carried away by the water used in the washing and dressing of metalliferous ores and earths.

(No Model.) 2 Sheets—Sheet 1. 974

G. ROBSON.

SEPARATION OF METALS AND METALLIC COMPOUNDS FROM ORES OR OTHER SUBSTANCES.

No. 575,669. Patented Jan. 19, 1897.

Fig. 1.

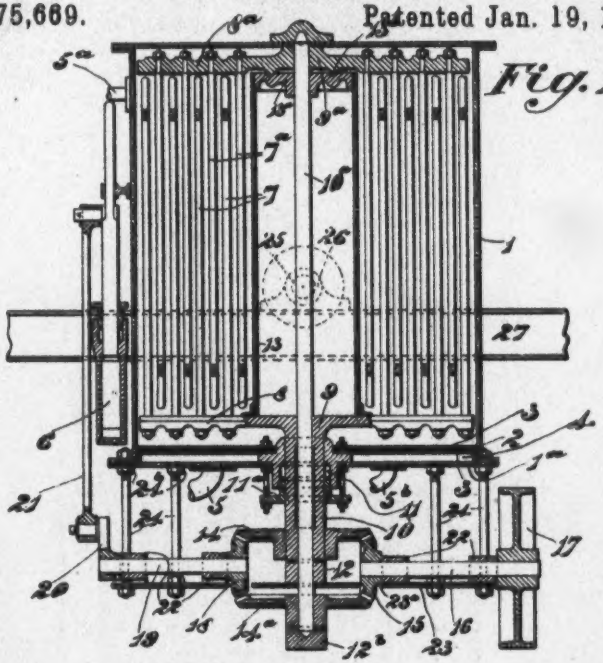


Fig. 2.

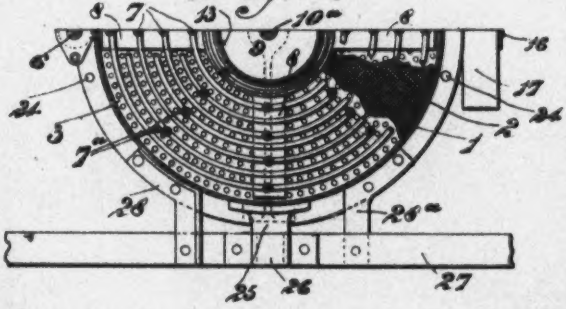


Fig. 3.

Witnesses.
E. E. Duffy
Hubert Steck

Inventor:
George Robson
per O. E. Duffy
Attorney

No. 259
MINERALS
tion, Ltd. et al.
v.
HYDE.
Page 974

(No Model.) 2 Sheets—Sheet 2. 975

G. ROBSON.

SEPARATION OF METALS AND METALLIC COMPOUNDS FROM ORES OR OTHER SUBSTANCES.

No. 575,669. Patented Jan. 19, 1897.

Fig. 4

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Witnesses
F. G. Berry
[illegible]

Inventor
Geo. Robson
per O. C. Duffy

as in crushing-machines, buddles, jigging-machines, vanning-machines, and the like. For this purpose the substances containing finely-divided metal or metallic compounds such as referred to, or both, (hereinafter referred to as metallic matter,) are brought into intimate contact with an oily liquid that is of less specific gravity than water, and is capable of taking up the said finely-divided metallic matter and thus separating it from the substances with which it was previously mixed.

I have found by experiment that a suitable liquid for the purpose mentioned can be obtained by mixing a liquid hydrocarbon, such, for example, as turpentine, petroleum, paraffin, or the like, with a fatty oil such as colza-oil, the production of fatty oil in the mixture varying say, for example, from about ten to twenty-five per cent. of the hydrocarbon according to the nature of the material to be treated. For example, when treating quartz containing gold and iron oxid for the recovery of the gold a smaller quantity, say ten per cent., of fatty oil should be used than when iron oxide is absent, in order that the iron oxid may not be removed with the gold. I prefer to use as the liquid hydrocarbon a mineral oil such as petroleum or paraffin on account of its cheapness. The fatty oil appears to play the principal part in the actual separation of the metallic matter, the liquid hydrocarbon acting the part of a diluent.

In carrying out my invention the finely-divided substances can, in a soft and plastic state, be brought into contact with the mixture of oils (hereinafter referred to as the oily liquid) in various ways. Thus the said substances in a moist or pasty state, due to admixture therewith of a small quantity of water, say from about twenty-five per cent. to thirty-five per cent. of water, may be mixed or agitated with the oily liquid in a suitable vessel in such a manner that the metallic matter present in the resulting mud or mass will be brought into intimate contact with the oily liquid, so as to be taken up thereby and be then carried to the surface of the mass, whence it can be run off, with a portion of the oily liquid, into a suitable settling vessel or separating device wherein the metallic matter is allowed to subside or is separated and from which the oily liquid is withdrawn for reuse.

In the accompanying drawings, Figure 1 is a vertical section, and Fig. 2 a half-sectional plan showing an arrangement of apparatus suitable for thus carrying out my invention. Fig. 3 is a detail view. Fig. 4 is a part plan of a settling vessel.

The apparatus, Figs. 1, 2, and 3, comprises a vessel 1, provided with a false bottom consisting, preferably, of finely perforated or reticulated sheet material 2, held between two stronger and coarsely-perforated plates 3, the space between this false bottom and the true bottom 1^a of the vessel forming a delivery-chamber 4, that
977 is placed by a pipe 5 in communication with a pump 6 for supplying the oily liquid thereto.

5^a is an exit-pipe for running off oily liquid laden with metallic matter into a separating device.

5^b is a pipe normally closed for draining off the oily liquid re-

maining in the vessel at the termination of the treatment of a charge of material.

Within the vessel are arranged two series of vertical stirring-rods 7 7^a, arranged to revolve in concentric circles and carried by horizontal arms 8 8^a, extending, respectively from hubs 9 9^a, fixed to or formed in one, with two rotary shafts 10 10^a extending through the bottom of the vessel. The shaft 10 passes through a stuffing-box 11 and is carried by a step-bearing 12, formed by a central portion of a curved bracket 12^a, (shown separately in Fig. 3,) the ends of which are secured to the bottom of the vessel. The hub 9 of this shaft may advantageously be provided with a centrally-arranged tubular extension 13, through which the shaft 10^a extends and which is closed at the top by a cover 13^a, formed with annular bearing 13^b, of V shape in cross-section, and adapted to receive a correspondingly-shaped annular ridge on the under side of the hub 9 and so prevent escape of material at this point. The rotary shaft 10^a extends through the shaft 10 and is carried by a second step-bearing 12^b, formed and arranged similarly to 12.

To the shafts 10 and 10^a are respectively fixed two bevel-wheels 14 14^a, that are in gear with a bevel-wheel 15, that is common to them and which is fixed upon a driving-shafe 16, provided with a driving-wheel 17.

18 is a bevel-wheel in gear with bevel-wheel 14 and fixed upon a shaft 19, having a crank 20, which serves to operate, through a connecting-rod 21, the pump 6, which may be of any suitable kind, such as a single or double acting plunger pump. The bearings 22 of the two shafts 16 and 19 are carried by a plate 23, which is suspended from the bottom of the vessel 1 by bolts 24 and is slotted at 23^a to accommodate the bevel-wheels 15 and 18.

To enable the bottom 1^a to be readily removed for gaining access to the chamber 4, the said bottom may conveniently be secured in place by nuts 24^b on the bolts 24 and the stuffing-box 11 be unprovided with the usual flange at its outer end, so that upon loosening the said nuts and the nuts upon the glandstuds the bottom can be lowered to an extent limited by the stuffing-box gland 11^a. The vessel is provided with trunnions 25, mounted in bearings 26, fixed upon two beams 27, so that it can be partly rotated, when necessary, to discharge its contents, at which time the driving-belt is removed from the driving pulley 17.

28 28^a are two brackets fixed to the vessel and adapted to bear against the upper and lower sides, respectively, of one of the beams 27, to which they are fixed by bolts to hold the vessel steady when the stirring mechanism is in operation.

The exit-pipe 5^a is arranged to deliver the oily liquid escaping from the top of the vessel into a separator having its outlet in connection with the suction of the pump 6, the arrangement being such that oily liquid can be caused to flow continuously through the finely divided and agitated substances in the vessel 1 and then be delivered with metallic matter taken up thereby into the separator, wherein such matter is separated from the oily liquid, which is drawn off by the pump for reuse.

In carrying out the invention the cover 13^a of the vessel 13 is removed, the finely-divided metalliferous substances in the form of a soft plastic mass, produced by previous admixture of water therewith, as set forth, is placed in the vessel, the cover replaced, the stirring-rods 7 7^a set in motion, and the oily liquid circulated continuously through the vessel and separator. By the agitation of the plastic mass with the oily liquid the finely-divided metallic matter present therein is brought into intimate contact with the oily liquid, which takes it up and carries it off from the gangue or earthy matter present, which, owing to its admixture with water, forms a soft plastic mass that is of greater specific gravity than the oily mixture and which is not disintegrated by and consequently disseminated through and carried off by the oily liquid. In this way the finely-divided metallic matter is separated from the gangue and floated or carried off by the oily liquid into the separator, where it is allowed to deposit by gravity, the gangue remaining in the form of a soft plastic mass at the bottom of the mixing vessel.

The separating device may conveniently consist of a settler of ordinary construction, consisting of a vessel 29, Fig. 4, provided with divisions or baffles 30, so as to form a zigzag course for the oily liquid, and in which the metallic matter is allowed to separate from the oily liquid by gravity, the oily liquid running off clear for reuse.

I am aware that it has been proposed to recover finely-comminuted metal from ores by the use of oils mixed with acids or salts by mixing the finely-divided ores with oils and acids or salts and afterward washing out the gangue with water, and also of mixing the ores with oils and then washing out the sand or gangue with water containing acid. I disclaim the use of acids or salts and also the method of washing away the gangue with water, both these methods being entirely dissimillar to the method herein described as constituting my invention, according to which I effect the separation of the metallic matter by the mixture of oils alone, using such mixture to wash out the metallic matter and avoiding as far as possible the presence of water much in excess of the quantity hereinbefore mentioned, as I find an excess of water prevents the successful carrying out of my invention.

It has been found that the oily mixture has an affinity or cohesion with the metallic particles greatly exceeding that for the non-metallic particles, so that when motion is imparted to the oil the traction of the oil, due to the aforesaid cohesion, is sufficient to overcome the gravital tendency of the metallic particles, while its cohesion for the non-metallic particles is insufficient to overcome the gravital tendency of said non-metallic particles. It follows that when such motion has been imparted to the oil the traction on the metallic particles is sufficient to carry such particles up while the non-metallic particles remain behind, a separation of the two being thus effected, the metallic particles being afterward separated from the oily mixture.

What I claim is—

1. The herein-described mode of separating and recovering

finely-divided metal and metallic compounds from finely-divid substances, which consists in intimately and thoroughly mixi said substances with a diluent liquid containing a fatty substan so that the metallic portions are taken up by the fatty substan then removing the oily liquid with metallic matter from the sa finely-divided substances and then separating the metallic mat from said oily liquid, substantially as herein described.

2. The method of recovering metals and metallic compoun from finely-divided substances, which consists in thoroughly an mechanically agitating and mixing a fatty oil with said substanc while the same are in a moist or plastic state due to admixture o water therewith, then drawing off the fatty oil carry the met particles, and metallic compounds from said substances, and the separating the metals and metallic compounds from the oil, sub stantially as described.

3. The herein-described mode of recovering metals and metall compounds from finely-divided substances in a moist state, whic consists in passing oil through the mass of finely-divided material s that the oil floats off the metallic portions against the force of gravity and removing the oil carrying said metallic particles and separatin the metallic portions therefrom, substantially as described.

4. The herein-described method of separating and recoverin finely-divided metal and metallic compounds from finely-divide substances which consists in forming said finely-divided substanc into a moist or pasty mass by admixture therewith of water, floa ing off finely-divided metallic compounds from said mass by agita ing the same with an oily liquid, drawing off the oily liquid, an separating therefrom the metallic matter carried off thereby, sub stantially as described.

5. The herein-described method of washing out metals and metal lic compounds from finely-divided substances, which consists in causing an oily liquid to flow in a practically continuous stream through the said substances while the same are in a stirred or agi tated state, separating the metallic matter from the oily liquid by gravity after it has been removed from the said substances, and afterward again bringing the oily liquid into contact with the said substances for reuse, substantially as herein described.

6. The combination of the horizontal supporting-beams, the closed separating vessel having the inlet and outlet pipes and the driving-gear at its lower end, said vessel having the lateral trun nions journaled in said beams and the lateral arms 28 and 28 above and below the planes of the beams as and for the purpose described.

7. The combination of the outer casing, the vertical shaft passing therethrough and at one end of the casing, having the disk pro vided with stirring-arms extending longitudinally of the casing, a sleeve on said shaft and turning oppositely thereto, a disk in the casing of the sleeve having the stirring-arms extending longitudi nally of the shaft and between the first-mentioned stirrer-arms, brackets at the lower end of the casing having bearings for the lower ends of the sleeve and shaft, and gears on the sleeve and

shaft provided with means for driving them in opposite directions, substantially as described.

8. For separating and recovering metallic matter from finely-divided substances containing the same, apparatus comprising a pivoted vessel having a perforated or reticulated false bottom and inlet and outlet passages for oily liquid, stirrers arranged within said vessel, a pump carried by said vessel and adapted to cause oily liquid to flow therethrough and mechanism carried by said vessel for driving said stirrers and pumps substantially as herein described.

9. In a separator, the combination of the cylindrical casing, the central longitudinal shaft therein, the disk of the shaft at one end of the casing having the stirrers, the sleeve turnable on the shaft, the disk on said sleeve in the opposite end of the casing having the stirrers extending between and parallel with the opposite stirrers, the central closed longitudinal clyinder 15, between and engaging said disks, and gearing rotating the sleeve and shaft in opposite directions, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

GEORGE ROBSON.

Witnesses:
PERCY ERNA HOCKS.
EDMUND S. SNEWIN.

979 [COMPLAINANTS' EXHIBIT DRAWINGS AND SPECIFICATION OF LETTERS PATENT No. 763,259, PATENTED JUNE 21, 1904, ISSUED TO A. E. CATTERMOLE.

(Here follows diagram marked p. 980.)

981 United States Patent Office.

No. 763,259, Patented June 21, 1904.

ARTHUR EDWARD CATTERMOLE, of London, England.

Classification of the Metallic Constituents of Ores.

Specification Forming Part of Letters Patent No. 763,259, Dated June 21, 1904.

Application Filed September 29, 1903. Serial No. 175,060. (No Specimens.)

To all whom it may concern:

Be it known that I, Arthur Edward Cattermole, a subject of the King of England, residing at London, England, have invented certain new and useful Improvements in the Classification of the Metallic Constituents of Ores, of which the following is a specification.

The present invention relates to the classification of the metalliferous constituents of ores which have been separated from gangue by oil or similar matter, such as certain wood or coal tar products, hereinafter referred to as "oil," in which term I also include the emulsifying agent when an emulsifying agent is present with the oil.

The invention consists in fractionally removing the different constituents from the agglomerated masses by freeing the constituents in turn from the oil, and thus obtaining them in a separable condition by the use of emulsifying agents of varying strength and activity, preferably in conjunction with an alkali.

In carrying out the process the metalliferous mineral matter agglomerated by oil is mixed and agitated with a solution of an emulsifying agent, such as a soluble soap—alkaline oleate, for example—to which a certain proportion of soluble alkali, preferably caustic potash or soda, has been added.

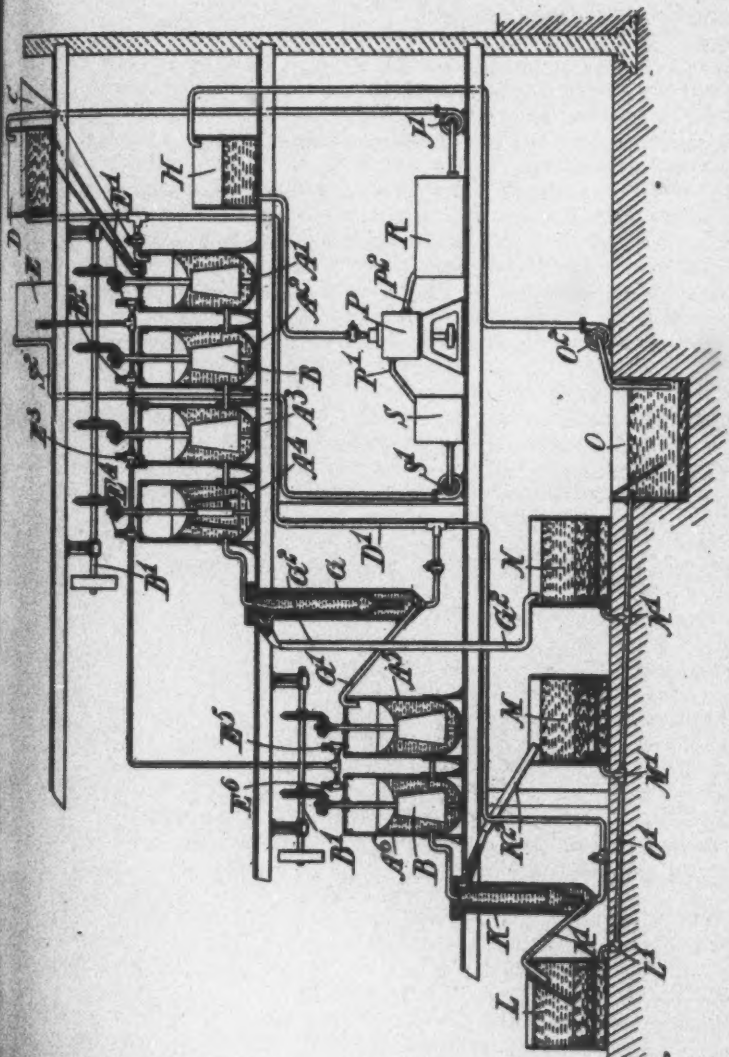
It is found that minerals vary in their affinity for oil employed in the above manner, and thus by treating the oily masses or granules in the first place with an alkaline emulsifying solution of a certain strength the mineral of least affinity can be separated therefrom and by increasing the strength or modifying the proportions

No. 762,959. PATENTED JUNE 21, 1904.

A. E. CATTERMOLE.

CLASSIFICATION OF THE METALLIC CONSTITUENTS OF ORES.

APPLICATION FILED SEPT. 29, 1903.



Witnesses:

Inventor:
Arthur E. Cattermole,

of the breaking-down solution step by step the various metalliferous constituents may be thrown out in the order of their increasing affinities. Taking, for example, an ore containing siliceous gangue, rosin-blende, copper pyrites, and galena, the ore is first treated with oil or emulsified oil for the granulation of the metalliferous mineral. The oil is preferably one such, for example, as a hydrocarbon oil which is not too readily emulsified and which gives a wide range of strength in the solutions required for breaking down the granules. The compound granules separated from the siliceous gangue and liquor are drained and run into the first classifying apparatus, where they are agitated with a solution, which may have, say, a strength of three-fourths of one per cent. soap (when this is the emulsifying agent employed) and of three-fourths of one per cent. alkali, by which the rosin-blende is dropped out. The granules remaining freed from blende and liquor are then passed onto a second similar apparatus in which a solution of a strength of, say, one and one-half per cent. soap, one and one-half per cent. alkali is used. Here the copper pyrites is freed and subsequently removed, the galena remaining still granulated. The oil may finally be recovered from these granules by the use of a solution of suitable—i. e., sufficient—strength of alkali and emulsifying agent, and its separation from the mineral may be promoted by attrition.

The strength of the breaking-down solutions required and the relative proportions of their constituents depend mainly upon the following conditions—that is to say, upon the state of fineness of the ore treated, the relative proportions of the contained minerals one to another, their physical condition and chemical composition, the nature of the oil, emulsifying agent, and alkali used.

The example above given indicates for an ore such as is there supposed to be under treatment and for the oil and emulsifying agent mentioned in what proportions these agents should be employed. In the case of another ore and of other reagents these proportions may need to be readjusted, and for the purpose of such readjustment the following rules may be laid down. The finer the ore the more compact and cohesive are the granules formed from it, other things being equal, and therefore stronger breaking-down solution will be required with a finely-ground ore than with one coarsely ground. With granules where minerals, such as galena, which offer great resistance to the breaking-down action of the solution preponderate the breaking-down solution should of
982 course be stronger or more active than in the alternative case, (where mineral such as rosin-blende, which offers less resistance to the breaking-down solution preponderates.)

In considering the chemical composition of the minerals it is of course necessary to bear in mind that a constituent mineral—say, for example, zinc-blende—may contain impurities or other metalliferous constituents (such as iron sulfid) which will materially affect their resistance to the breaking-down action of the solution, in the case supposed increasing such resistance.

With regard to the nature of the oil: With the animal or vegetable oils or readily-emulsified oils the breaking down is compara-

tively rapid and may be too rapid for conveniently carrying out this process. With heavy residuum oils and other heavy hydrocarbon oils, which are emulsified with difficulty, the breaking down is comparatively difficult and slow. Oils may be blended for the purpose of obtaining a mixture which suits the requirements of any particular mineral mixture which may be under treatment. The breaking down is effected most advantageously with emulsifying agents and alkali which are readily soluble. Bearing these principles in mind, the operator will always be able to determine by observations made in the course of working, or, if he so prefers, by a few simple preliminary tests, under what conditions this process can be worked to the best advantage.

In the upcurrent or other separating device for removing the freed mineral from the granules remaining solution of the same strength as that used in "breaking down" may be employed, or it may be somewhat weakened by dilution, so long as the reagglomeration of the separated mineral does not take place.

The more or less emulsified oil removed from the granules separates out as a "cream" or concentrated emulsion from the breaking-down solution employed, and the separation of such oil for reuse in the various stages and recovery of oil-depleted solution for reuse in the breaking-down stage may be hastened by the employment of mechanical separators. Since oil is being removed in each breaking-down stage, it is generally preferable to start with the compound mineral granules in a rather soft or pasty condition by the use of a sufficiency of oil in the granulating stage, or, if necessary, the granules from one stage if reduced too small by removal of oil for ready separation may be again treated with oil or oil emulsion, or oil or oil emulsion may be added to the breaking-down solutions in the requisite small amounts to keep the granules of proper size and consistency to be dealt with in the separating devices in use. The presence of a certain amount of oil in the solutions assists separation by preventing the too ready breaking down of the granules.

The separated minerals may be drained or treated in centrifugal or other mechanical solution-extractors for the closer recovery of solution and drying of the product.

The accompanying drawing is a diagram illustrating in sectional view one method of carrying out the process according to this invention as applied to a mixed sulfid ore—Broken Hill ore, for example—consisting of galena and blende.

A series of connected mixing vessels A' A^2 A^3 A^4 A^5 A^6 are provided with stirrers B, rotated from driving-shafts B'. The oily granulated mixture of galena and black blende freed from the gangue from the hopper C and breaking-down solution, which may have a strength of one-half of one per cent. alkaline oleate and one and one-half per cent. caustic alkali, from a tank D are introduced into the first vessel A', and the oil or emulsion needed to keep the granules of suitable size and consistency is fed as required from the tank E through pipes and regulating-taps E' E^2 E^3 to the various vessels. The mixture is vigorously agitated to break down the mixed granules and liberate the blende. After agitating to a certain extent

(in four communicating vessels, as illustrated, for example,) the mixture is passed into an upcurrent classifier G, which is supplied with solution from the tank D through a pipe D'. The partly-broken-down granules and the heavier particles of liberated blende are discharged through a pipe G' into the vessel A^5, while the lighter particles of blende are carried away by the upward current and discharged through outlet-pipe G^2 to the tank N, provided with a filter-bottom for the draining of the product. The solution is allowed to run by the pipes N' and O' into a tank O, from which the solution may be returned by the pump O^2 to the tank H. The granules and coarser blende are subjected to further agitation in the vessels A^5 A^6, where the separation of the blende is completed, and are then passed into a second classifier K, from which the galena granules are removed at the bottom by the pipe K' into the tank L, while the blende is discharged from the upper pipe K^2 into the tank M. Like N the tanks L M are provided with a filter-bottom, and the solution that drains away is led by the pipes L' M' and pipe O' into the tank O for pumping up to the tank H. The solution thus returned to this tank contains the oil removed from the granules and is thence run into a centrifugal separator P, whence the oil escapes through a pipe P' to a tank S, while the solution, deprived more or less completely of oil or oil emulsion, runs into a tank R and is thence returned by the pump J' to the feed-tank D for reuse. The separated oil or oil emulsion in the tank S is returned by the pump S' through a pipe S^2 to the oil or emulsion tank E. This apparatus is illustrated only as one convenient method of carrying out this
983 & 984 invention, and it is to be understood that its nature and arrangement can be considerably varied.

The process, it will be seen, comprises two steps which are essentially distinct—first, the removal of certain constituents from the agglomerated masses or granules, and, second, the separation of the material so removed from the remaining granules. In the apparatus described and illustrated in the accompanying drawing, I have provided for the carrying out of these two stages of the process in separate vessels, (mixers and separators, respectively;) but it will be readily understood that the apparatus and process can, if desired, be so modified that all the operations may be carried on in a single vessel, and similarly the various parts of the apparatus may be modified in a great many ways to suit special conditions of working.

In some cases, as when one of the mineral constituents is small in amount, particularly when among the last to be separated, it may be increased up to the required point for ready separation by incorporating the requisite amount with the initial mixed granules or by addition to the product in the apparatus in which the breaking down is effected. A certain amount of already-separated mineral may be returned for this purpose, or where, owing to the absence of sufficient fine or slime material weakly-coherent granules breaking down too readily are obtained, such fine mineral may be added, as described, to render such granules more coherent and resistant. In other cases with the same object in view it may be advantageous to subject the granulated mixed mineral to grinding action to further

reduce the size of the constituent mineral particles without destroying the agglomeration before breaking down and separation of the constituents.

When minerals granulated with some tarry products are treated an alkaline breaking-down solution with an emulsifying agent of analogous nature may with advantage be employed. For example when granulated with wood-tar an alkaline solution of the tar in suitable proportions and strength is the most suitable liquor to be employed for breaking down and separation of the minerals.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The herein-described process of classifying metalliferous minerals agglomerated by oil which consists in successively agitating the agglomerated mineral with emulsifying agents of varying strength progressively to free the several minerals in succession.

2. The herein-described process of classifying metalliferous minerals agglomerated by oil which consists in successively agitating the agglomerated mineral with emulsifying agents of varying strength progressively to free the several minerals in succession separating out each mineral in turn by a separating device and adding oil in the requisite small amounts to keep the granules of proper size and consistency.

3. The herein-described process of classifying metalliferous minerals agglomerated by oil which consists in successively agitating the agglomerated mineral with solutions of soap and caustic alkali of varying strength progressively to free the several minerals in succession.

4. The herein-described process of classifying metalliferous minerals agglomerated by oil which consists in successively agitating the agglomerated mineral with solutions of soap and caustic alkali of varying strength progressively to free the several minerals in succession and separating out each mineral in turn by an upward current.

5. The herein-described process of classifying metalliferous minerals agglomerated by oil which consists in successively agitating the agglomerated mineral with solutions of soap and caustic alkali of varying strength progressively to free the several minerals in succession separating out each mineral in turn by an upward current and adding oil in the requisite small amounts to keep the granules of proper size and consistency.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ARTHUR EDWARD CATTERMOLE.

Witnesses:
HASOP WADE.
HARRY S. GRIDGE.

No. [illegible]
MINERALS
Separation, Lab. et al. | Page
v.
MYOM.

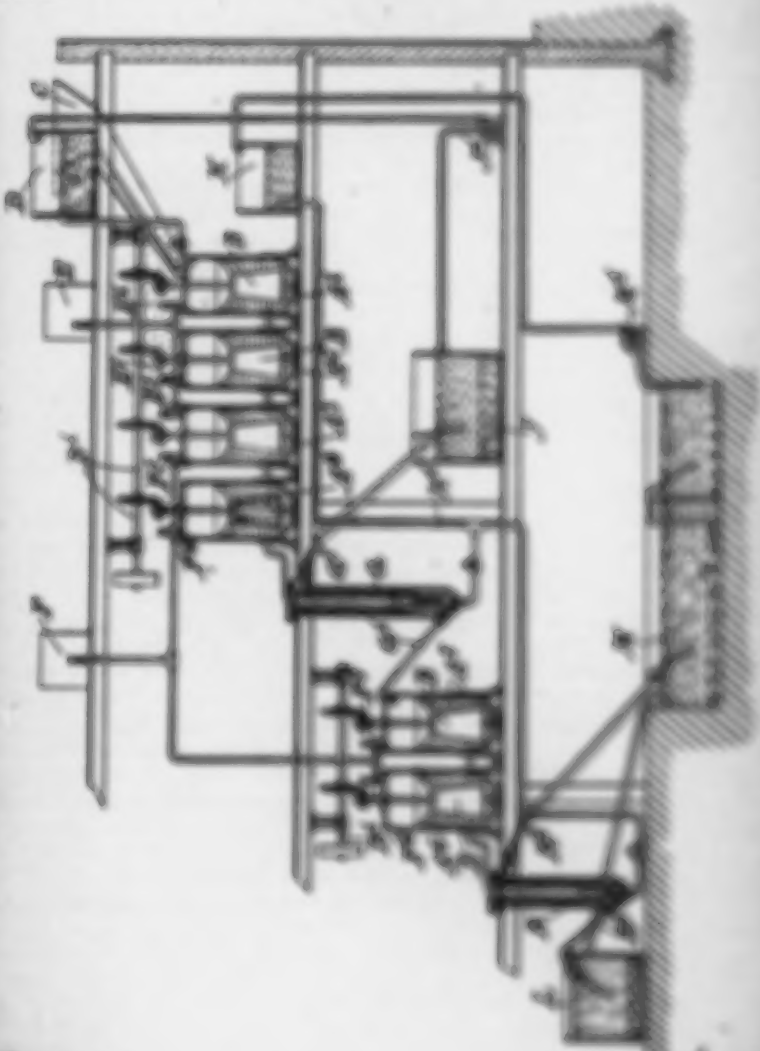
No. [illegible]. PATENTED JUNE [illegible], [illegible].

A. E. CATTERMOLE.

SEPARATION OF THE METALLIC CONSTITUENTS OF ORES FROM GANGUE.

APPLICATION FILED JAN. [illegible], [illegible].

[illegible] MODEL.



985 [COMPLAINANTS' EXHIBIT DRAWING AND SPECIFICATION OF LETTERS PATENT No. 763,260, PATENTED JUNE 21, 1904, ISSUED TO A. E. CATTERMOLE.]

(Here follows diagram marked p. 986.)

987 No. 763,260, Patented June 21, 1904.

United States Patent Office.

ARTHUR EDWARD CATTERMOLE, of Highgate, London, England.

Separation of the Metallic Constituents of Ores from Gangue.

Specification Forming Part of Letters Patent No. 763,260, Dated June 21, 1904.

Original application filed September 28, 1903, Serial No. 174,947. Divided and this application filed January 2, 1904. Serial No. 187,599. (No specimens.)

To all whom it may concern:

Be it known that I, Arthur Edward Cattermole, a subject of the King of England, residing at Highgate, London, England, have invented certain new and useful Improvements in the Separation of the Metallic Constituents of Ores from Gangue, of which the following is a specification.

This application is a division of my application filed September 28, 1903, Serial No. 174,947.

The present invention relates to improvements in the separation of the metalliferous constituents of ores and the like from gangue by means of the selective action of oils and certain tar products or similar compounds (all hereinafter referred to as "oil") on metallic or metalliferous matter.

The invention depends upon the application of the following facts: First, when a mixture of powdered metalliferous matter and gangue is treated with oil suspended in water—that is to say, in emulsion—the oil has a more or less selective action and will coat the particles of metalliferous matter in preference to the particles of gangue, while the particles of gangue will be wetted by the water; second, if the water be made alkaline and an emulsifying agent, such as soap, be present the selective action of the oil will be rendered more marked and decisive; third, if the proportion of oil is kept within reasonably low limits (differing in different cases, according to the nature of the mineral to be treated and the con-

sistency and nature of the oil) and if the mixture of water, oil, metalliferous particles, and gangue be thoroughly agitated, the metalliferous particles which have become coated with oil will adhere together and form granules, which granules, partly by reason of gravity or partly on account of their bulk as compared with the individual grains of gangue, will offer ready means for separation in an upcurrent-separator, a jig, or other similar appliance. This action is facilitated if the oil before addition to the liquor is brought into the condition of an emulsion in water containing a small percentage of free soap.

In some cases the pulp may contain mineral acid. Alkali must then be added in sufficient quantity to neutralize the acid and to leave some alkaline soap undecomposed—that is, free.

These facts are utilized for the purpose of separating the metalliferous constituents from the gangue of the ore in the following manner: In a suitable apparatus, an example of which will be hereinafter described, the ground or pulped ore is caused to be violently agitated, as by a revolving stirrer, in a mixture of water and oil, the liquor containing an alkaline emulsifying agent. As the agitation proceeds the particles of metalliferous matter agglomerate together and may be observed in the form of granules, the size of which will depend, among other things, upon the percentage of oil used. This granulation of the metalliferous constituents of the ore affords the means by which at a later stage of the process it is possible to separate the metalliferous material from the gangue, as will be hereinafter particularly described. In practice a continuous process is used—that is to say, water, ground ore, or pulp and oil, preferably emulsified, are continuously fed into a series of vessels and the products of the agitation are continuously fed into an upcurrent-separator or jig or similar device which in the case of the upcurrent-separator separates the metalliferous granules from the gangue by allowing them to fall to the bottom of the vessel and to be carried away by a downward stream, while the particles of gangue are carried away by an upward stream.

The accompanying drawing is a diagram illustrating in sectional view one means of carrying out the process according to this invention.

A series of connected mixing vessels A' A^2 A^3 A^4 A^5 A^6 are provided with stirrers B, rotated from driving-shafts B'. Crushed ore from a hopper C and circuit-water from a tank D are introduced into the first vessels A', and oil or emulsion is fed from a tank E, through pipes E' E^2 E^3, to the various vessels. The mixture is vigorously agitated to break up and emulsify the oil and to
988 bring about intimate contact of the divided oil with the metalliferous mineral particles and of the oiled particles with each other. An alkaline emulsifying agent, such as soap, is introduced into one or more of the vessels from a tank F, having discharge-pipes F^3 F^4 F^5 F^6. It is found under these conditions that the metalliferous mineral particles abstract the oil and become coated with a thin oily film which is insufficient to materially lessen their specific gravity and that under agitation such slightly-oiled

particles adhere, nucleate, and agglomerate into small more or less rounded masses or granules disseminated throughout the mass of gangue, which remains free and practically devoid of oil. After agitation to a certain extent (in four vessels, as illustrated, for example) the mixture is passed into an upcurrent-classifier G, which is supplied with a stream of circuit-water from a tank H through a pipe H′. As the granules remain specifically heavier than the gangue or can by suitably adjusting the amount of oil and the agitation be obtained of a size larger than that of the gangue particles, the granules, with a certain amount of heavy sands, sink to the bottom and are discharged through a pipe G′ into vessel A^5, while the lighter sands are carried away by the upward current and discharged through outlet G^2 to a light-sands tank J, from which the circuit-water may be returned by a pump J′ to the feed-tank D for reuse. In order to separate the granules from the heavy sands, the mixture is subjected to further agitation in the vessels A^5 A^6 and is then passed into a second classifier K, from which the granules are removed at the bottom by the pipe K′ into the metalliferous-mineral tank L, while the heavy sands are discharged from the upper pipe K^2 into a heavy-sands tank M. The circuit-water from the tanks L and M is returned by a pump N′ to the feedwater tank H. This apparatus is illustrated only as one convenient method of carrying out this invention, and it is to be understood that its nature and arrangement can be considerably varied.

The water throughout the circuit is alkaline and contains a suitable proportion of soap or other emulsifying agent. The agitation vessels may be separate, with arrangements for charging and discharging, the charging with pulp and the addition of oil or emulsified oil and the agitation and discharge successively in the series of vessels being so timed that the output of treated ore is kept continuous and constant. The classifiers used may be jigs, shaking-tables, or the like or sizing apparatus whereby the comparatively larger mineral granules may be separated from the finer gangue, and one or more classifiers may be employed.

The proportion of oil used depends upon its viscosity, the fineness of the ore, and other factors, and the consistency and size of the mineral granules desired. The more oil used the larger, softer, and less numerous the granules. With, say, ten per cent of oil to the weight of metalliferous mineral a few pasty masses of oil agglomerated metalliferous mineral matter will generally result. Oil in excess of this may cause all the granules to coalesce into one soft mass. Usually an amount of oil varying from four per cent to six per cent of the weight of metalliferous mineral matter present in the ore yields granules of suitable size, consistency, and specific gravity for ready separation from the gangue in the uppercurrent or other apparatus used for classification.

The amount of emulsifying agent, if used to form the oil-emulsion, depends upon the viscosity and nature of the oil. When soap is employed, an amount varying from three per cent. to five per cent. of the weight of oil usually suffices, this being dissolved in,

say, ten times its weight of water. For emulsification a low alkalinity of the emulsifying agent is generally best.

The oil used may be animal, vegetable, or mineral oil, or mixtures of these, or such coal or wood tar products or other substances which exercise, like oils, a preferential physical affinity for metallic mineral matter as distinguished from gangue.

The emulsifying agent may be any substance capable of holding the oil in a fine state of division in suspension in water without acting on the mineral matter or preventing the action of the oil—for example, soap, alkaline cresylates, or other substances solutions of which in water froth on agitation. The emulsifying agent appears to have a decided effect in bringing about the granulation as described. In some cases, as with wood-tar and some coal-tar products, these when agitated in weak alkaline solutions provide their own emulsifying agents, soluble resinates, cresylates, &c., being thereby formed, which emulsify the bulk of the tar or product.

Emulsification in some cases, as with the heavier residuum oils or tars, may be assisted by first mixing therewith a small amount of fatty oil or fatty acid. Preferably one emulsifying agent is employed throughout the process.

In order to recover the oil from the granules after their separation from the gangue, they may be agitated with the emulsifying agent in a stronger or more active condition or proportion than was used in the emulsification of the oils initially, and the action of this emulsifying agent in stripping the oil from the metalliferous mineral particles may be aided by attrition. The strengthening of the emulsifying agent may be effected by increasing the proportion of the agent or of the alkaline base in solution, or both, the percentage strength of the solution needed depending upon the oil used and the nature of the metalliferous mineral matter with
989 & 990 which it is associated. Usually if oleic soap is employed and caustic potash amounts varying from one-quarter of one per cent. to three per cent. or four per cent. of one or the other in solution suffices, the less readily emulsified oils, as the residuum oils, requiring the larger amounts. The removed oil is obtained as a dilute emulsion, which on standing some time separates. The "cream" or concentrated emulsion may then be used for making fresh emulsion for treating fresh ore. To hasten this separation of cream, mechanical devices may be employed.

Generally with wet crushed ore removal of the bulk of the water for reuse in the mill is necessary. In such case the pulp is settled and the wet ore only fed into the agitators, emulsifying agent of suitable strength being added to thin them. The circuit of such liquids can thus be kept distinct from that of the mill-water, suitable arrangements being made for settling the mineral-depleted sands and slime and for addition of emulsifying agent and fresh water as required from time to time.

In certain cases, as where but little mineral is present in the ore, to increase the nucleating or granulating factor pulverized mineral matter obtained in a previous operation or other matter having an affinity for oil from a different source may be introduced into the

ore, or a portion of already granulated and separated mineral matter may be returned to maintain the necessary amount of mineral in the ore under treatment.

In carrying out the processes the ore may be roughly sized into two or more parts, which are then treated separately. With certain ores it may be preferable to use in some stages of the process a rolling form of agitation, as in cylinders or barrels, to obtain good granulation of the mineral.

It is preferable to use circuit-waters of varying degree of alkalinity, according to the nature of the mineral being treated, provided always that about one-half of one per cent. of soap or other emulsifying agent is present.

It is found advisable to keep the amount of free alkali low in proportion to the free soap present when such is the emulsifying agent used. Thus in one example 0.25 per cent. of free soap with 0.025 per cent. of free alkali was sufficient to keep calcite free from oil, 0.3 per cent. free soap and 0.03 per cent. free alkali kept quartz free from oil, while rather stronger solutions—as, for instance, 0.5 per cent. free soap and 0.05 per cent. free alkali—prevented garnet from becoming oil-coated. These figures refer to cases where a light oil was used—namely, paraffin. When the free soap was increased to about one per cent. or when the free alkali was increased to about one-fourth of one per cent., difficulty was found in agglomerating certain metalliferous substances, such as rosin-blende and iron or copper pyrites. Care must therefore be taken that neither the soap nor the alkali is in excess of that required for preventing agglomeration of the gangue.

I am aware that the selective action of oils and the like on metallic matter has been made the basis of previous processes for separating the metalliferous constituents of ores from gangue. For example, oil has been used to float off metalliferous mineral from ore-pulp, and its use has also been proposed to form a pasty mass of crushed ore from which the gangue could afterward be washed out by means of water, and I do not claim the employment of oil in any such manner.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The herein described process of separating metalliferous matter from gangue, which consists in agitating a mixture of powdered ore and water with oil in emulsion in water containing an alkaline emulsifying agent, so as to agglomerate the oil-coated particles into granules, and subjecting the mixture to classification to remove the small non-coated particles from the granules.

2. The herein-described process of separating metalliferous matter from gangue, which consists in agitating a mixture of powdered ore and water with oil in emulsion in water containing an alkaline emulsifying agent, so as to agglomerate the oil-coated particles into granules, and subjecting the mixture to upcurrent classification to remove the small non-coated particles from the granules.

3. The herein-described process of separating metalliferous matter from gangue, which consists in forming granules by agitating

a mixture of powdered ore and water with oil in emulsion in water containing an alkaline emulsifying agent, separating out the light sands, and thereafter further agitating the pulp to increase the size of the granules and separating out the heavy sands from the granules.

4. The herein-described process of separating metalliferous matter from gangue, which consists in agitating a mixture of powdered ore and water with oil in emulsion in water containing an alkaline emulsifying agent, adding particles of material having an affinity for oil to assist in the formation of granules or oil-coated particles, and subjecting the mixture to classification to remove the small non-coated particles from the granules.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ARTHUR EDWARD CATTERMOLE.

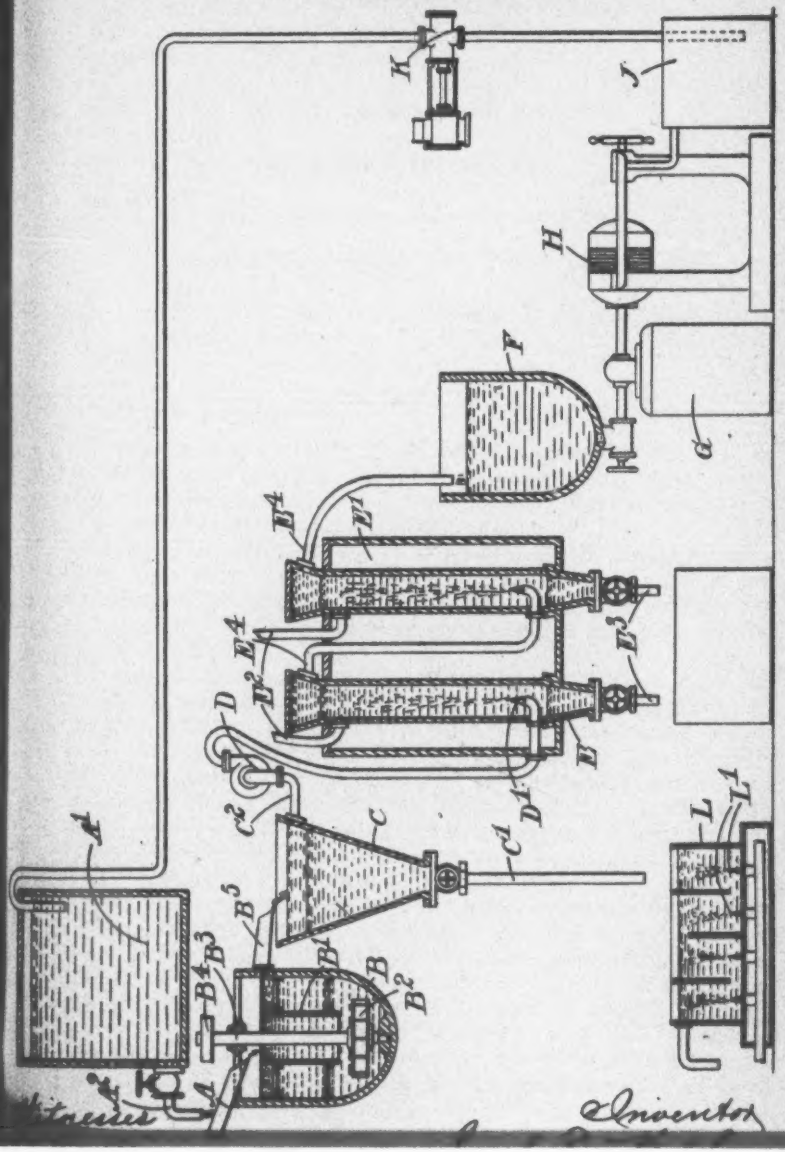
Witnesses:
CHRISTOPHER BARNETT.
WALTER J. SKERTEN.

No. 787,814. PATENTED APR. 18, 1905.

J. D. WOLF.

SEPARATION OF METALS FROM THEIR ORES.

APPLICATION FILED MAY 22, 1903.



991 COMPLAINANTS' EXHIBIT DRAWING AND SPECIFICATION OF LETTERS PATENT NO. 787,814, PATENTED APRIL 18, 1905, ISSUED TO J. D. WOLF.

(Here follows diagram marked p. 992.)

993 No. 787,814, Patented April 18, 1905.

United States Patent Office.

JACOB DAVID WOLF, of London, England.

Separation of Metals from Their Ores.

Specification Forming Part of Letters Patent No. 787,814, Dated April 18, 1905. Application Filed May 22, 1903. Serial No. 158,346.

To all whom it may concern:

Be it known that I, Jacob David Wolf, a citizen of the United States, residing at London, England, have invented certain new and useful Improvements in the Separation of Metals from Their Ores, of which the following is a specification.

The present invention relates to improvements in obtaining metals from their ores, the object being to separate the valuable and metallic-mineral constituents of an ore from its gangue by the use of oil or grease, particularly oil or grease which has been treated with chlorid of sulfur.

According to this invention the ore-pulps are agitated with oil, preferably mineral oil mixed with viscous animal or vegetable oil and treated with chlorid of sulfur, until the oil has taken up all the metallic-mineral contents with some gangue. The mineral-bearing oil is separated from the pulps, and suspended particles of gangue are removed from the oil by passing it through warm water, the metallic minerals being thereafter separated out from the oil, which can be used again. At the same time oil is recovered from the waste pulps by blowing air through them.

In order to increase the viscosity of certain mineral oils, a small proportion—say five per cent.—of animal oil, such as lard-oil, may be added before sulfo-chlorinating. Vegetable oils—such as rape, castor, or linseed oil—act in a similar manner. With pulps having a large proportion of mineral, as in the case of copper, lead, or zinc ores, the prepared oil should be made thick and viscous to produce the necessary power of flotation; but with pulps in which the percentage of mineral is small, as with gold ores, the oil need

not be thickened to the maximum extent. In the same way if the particles of mineral are coarse the oil should be specially viscous, while with fine particles the oil may be relatively thinner.

The accompanying drawing is a diagrammatic sectional view of apparatus suitable for use in carrying out this process.

In the following description it is assumed that the oil is treated with chlorid of sulfur; but it is to be understood that the same process and apparatus would apply to other suitable but untreated oils.

The ore mixed with water is crushed into a pulp and is introduced by a launder A into a mixer B, the oil, preferably treated with chlorid of sulfur, being simultaneously run in from the tank A′ through the pipe A^2. The mixing vessel B has a vertical hollow cylinder B′ fixed in the middle of it, and below the cylinder is a turbine-wheel B^2 on a vertical shaft B^3, rotatable through the pulley B^4. The mixture of oil and pulps passes into the hollow cylinder B′, and the rotation of the turbine-wheel B^2 causes a rapid circulation of the mixture downward within the cylinder and upward between the cylinder and the vessel B. The liquid is continuously discharged from the mixer through the pipe B^5 and passes into a separating-tank or spitzkasten C. Here the sulfo-chlorinated oil adhering to the mineral of the ore floats, while the gangue remaining in admixture with the water sinks and is removed by the waste-pipe C′. The mineral-bearing oil passes off from the surface through the conduit C^2. The mixture is next forced—for example, by means of a rotary pump D—in at the bottom of a vertical cylindrical vessel E, containing warm water and surrounded by a steam or hot-water jacket E.′ The vessel is provided with a water-inlet pipe E^2 and a waste-outlet E^3 at the bottom, and an oil-outlet E^4 is also provided near the top of the vessel. The oil mixture carrying particles of gangue in suspension is passed into the vessel E, preferably through a perforated inlet D′, to break the oil into thin streams or globules, which rise through the warm water and drop out the gangue in their upward course on account of the decrease in viscosity. If desired, two or more of these vessels may be used in series, the mineral-bearing oil being removed from the surface of each vessel. By the means thus provided for eliminating gangue it is possible to treat ores with such a degree of agitation that the whole of the mineral contents are taken up by the oil, accompanied, however, by a not inconsiderable proportion of gangue; but as practically all this gangue is removable from the oil by a
994 sufficient treatment with hot water much cleaner and sharper concentrates can be obtained than would be the case under any circumstances without such washing. The oil carrying practically only the values is next passed into a receiver F, from which it is forced, by means of a pneumatic forcing apparatus G, into a filter-press H, which may be of any suitable form—for example, of the type now largely used in the treatment of lard, tallow, and similar oils by fullers' earth. The separated oil is received in a tank J and is returned, by means of a pump K, to the oil-supply tank A′ to be mixed with fresh quantities of pulps, the

process being thus rendered cyclic. The properties of the oil are permanently altered by treatment with chlorid of sulfur; but it may be found advisable to add a further quantity of chlorid of sulfur after the oil has been in use for some time.

The waste pulps removed from the bottom of the settling-tank C are collected in a vessel L. After agitating the pulps with the oil oil-globules, which from various causes are not completely separated by flotation, but remain in the waste pulps, can be largely separated therefrom and recovered by blowing a current of air or air and steam through jets L′ upward through the waste pulps. The oil-globules rise to the surface and break, forming a film which is not liable to sink again and can be recovered by skimming or by surface baffles or the like.

It is to be understood that the form of the apparatus used can be varied without departing from this invention. For example, when separating the suspended gangue from the oil any convenient means may be used for passing the oil through warm water, and in removing the oil from the waste pulps currents of air or steam may be produced in any way. Also any other suitable method separating the values from the oil may be adopted.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The herein-described process of separating metals from their ores which consists in agitating pulps with oil until the oil has taken up all the metallic-mineral contents with some gangue, separating the mineral-bearing oil from the pulps, removing suspended particles of gangue from the oil by passing it through warm water and separating metallic minerals from the oil.

2. The herein-described process of separating metals from their ores which consists in agitating pulps with oil until the oil has taken up all the metallic-mineral contents with some gangue, separating the mineral-bearing oil from the pulps, removing suspended particles of gangue from the oil by passing it through warm water, separating metallic minerals from the oil which can be used again and recovering oil from the waste pulps by blowing air through them.

3. The herein-described process of separating metals from their ores which consists in agitating pulps with sulfo-chlorinated oil until the oil has taken up all the metallic-mineral contents with some gangue, separating the mineral-bearing oil from the pulps by flotation and removing suspended particles of gangue from the oil by passing the finely-divided oil upward through warm water.

4. The herein-described process of separating metals from their ores which consists in agitating pulps with sulfo-chlorinated oil until the oil has taken up all the metallic-mineral contents with some gangue, separating the mineral-bearing oil from the pulps by flotation, removing suspended particles of gangue from the oil by passing the finely-divided oil upward through warm water and filter-pressing the oil to separate out the metallic minerals from the oil.

5. The herein-described process of separating metals from their

ores which consists in agitating pulps with mineral oil mixed wi
viscous oil and treated with chlorid of sulfur until the oil has tak
up all the metallic-mineral contents with some gangue, separatin
the mineral-bearing oil from the pulps by flotation, removing su
pended particles of gangue from the oil by passing the finely
divided oil upward through warm water, filter-pressing the oil a

CLAUDE McKENZIE.

6. The herein-described process of separating metals from the
ores which consists in agitating pulps with mineral oil mixed wi
viscous oil and treated with chlorid of sulfur until the oil has tak
up all the metallic-mineral contents with some gangue, separatin
the mineral-bearing oil from the pulps by flotation, removing su
pended particles of gangue from the oil by passing the finely
divided oil upward through warm water, filter-pressing the oil a
separate out the metallic minerals from the oil and removing oi
globules from the waste pulps by spraying jets of air and caus
upward through the pulps and skimming off the oil which floats.

In testimony whereof I have signed my name to this specificatio
in the presence of two subscribing witnesses.

JACOB DAVID WOLF.

Witnesses:
CLAUDE McKENZIE.
H. D. JAMESON.

[illegible]

[illegible]

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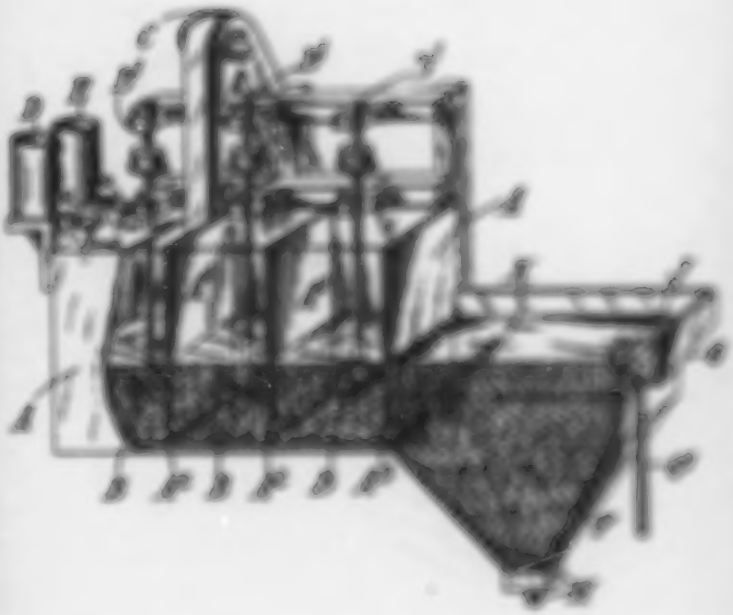

[illegible]

996. [COMPLAINANTS' EXHIBIT DRAWINGS AND SPECIFICATION OF LETTERS PATENT No. 763,260, PATENTED APRIL 5, 1910, ISSUED TO T. J. HOOVER.]

(Here follows diagram marked p. 998.)

997 United States Patent Office.

953,748, Patented Apr. 5, 1910.

THEODORE JESSE HOOVER, of London, England, Assignor to Minerals Separation Limited, of London, England.

Apparatus for Ore Concentration.

Specification of Letters Patent.

Application Filed March 17, 1909. Serial No. 483,971.

To all whom it may concern:

Be it known that I, Theodore Jesse Hoover, a citizen of the United States of America, residing at London, England, have invented certain new and useful Improvements in Apparatus for Ore Concentration, of which the following is a specification.

This invention relates to improvements in apparatus for ore-concentration.

Several processes are known in which air is beaten into a liquid containing powdered ore in suspension, whereupon the bubbles of air attach themselves to certain particles which are thereby caused to float, while other particles are not so floated.

The object of this invention is to improve the apparatus used in this type of process.

The invention is applicable to the process described in the United States patent of Sulman, Picard and Ballot, No. 835,120, Nov. 6, 1906, in which the liquid wherein the ore is suspended contains a small proportion of oleic acid or other oil. The invention is also applicable to processes in which no oil is used.

When air is beaten into the liquid in which the ore is suspended after which the liquid is introduced into a settling vessel, the object is that the air bubbles rising to the surface of the liquid in the settling vessel should form a froth carrying the particles of metallic sulfids. In certain forms of apparatus hitherto used, a proportion of the air escaped out of the liquid or collected into large bubbles before the liquid was brought into the settling vessel, and some of the effective floating power of the air was therefore lost.

According to this invention, an apparatus for concentrating ores by gaseous flotation of certain mineral particles comprises the combination with an agitating vessel in which the liquid containing powdered ore in suspension is agitated so as to beat air into it, of a spitzkasten or like settling vessel placed immediately at the outlet of the agitation apparatus, whereby the air beaten into the liquid is most effectively used for the purpose of flotation.

Another feature of this invention consists in the employment in such an apparatus of a guide, such as a baffle or deflecting plate, arranged at the inlet of the settling vessel in such a way as to direct the stream of mineral particles and air-bubbles toward the surface of the liquid, whereby a particularly effective flotation froth is obtained.

The accompanying drawing is a diagram in perspective, illustrating one form of apparatus embodying this invention.

Several agitation vessels A are placed in series. These may conveniently be large vats separated by partitions A^1 having openings A^2 at the bottom so that the liquid may pass from one to another. Each vessel is provided with a rotatable stirrer B which is conveniently of the form shown in the drawing. Each stirrer is carried on a spindle B^1 rotated at a high speed by any convenient means.

Crushed ore or similar finely divided mineral is fed into the first vessel A through any convenient ore-feeding device such as C, and water is also fed into the vessel A. A small proportion of acid, such as sulfuric acid, may be introduced into the water from the feeding vessel D, and a small proportion of one or more other substances which enable metallic sulfids to be floated by air under the conditions hereafter specified, may be introduced from the feeding vessel E. The circuit-water may be cold or may be heated to any suitable temperature. The liquid containing ore in suspension is vigorously agitated in the agitation-vessels and escapes at the outlet A^2 highly charged with air.

A settling apparatus consisting of one or more spitzkasten F, is placed immediately at the outlet from the agitation apparatus. As shown in the drawing, the spitzkasten F has a launder G to receive the floating froth which passes away through the outlet G^1. The liquid and the sunken material pass out through the outlet H at the bottom of the spitzkasten. The level of the liquid in the spitzkasten is slightly above the lip J. Within the spitzkasten is placed an inclined baffle or guide-plate K, which may be made adjustable, extending upward from below the inlet A^2 and arranged to direct the stream of ore-particles and air-bubbles toward the surface of the liquid in the spitzkasten. The result of the use of this arrangement is that the liquid passes out of the agitation apparatus directly into the spitzkasten, whereupon the little bubbles of air rise to the surface carrying with them the mineral particles to which they are attached.

998 The fact that the spitzkasten is placed immediately at the outlet of the agitation apparatus insures that practically all the air introduced into the liquid shall be utilized for flotation purposes and the position of the baffle K assists the air-bubbles in carrying the metallic sulfid particles to the surface while the gangue,

which is not attached to the air-bubbles, falls when it passes over the top of the baffle. The liquid which passes out of the bottom of the spitzkasten may, in addition to gangue, contain some metallic sulfids and it may therefore be again submitted to agitation and settling in a similar apparatus.

What I claim as my invention and desire to secure by Letters Patent is:—

1. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, the combination of, an agitation vessel, a spitzkasten contiguous thereto, said vessel and spitzkasten adapted to contain circuit liquid, means for agitating the contests of the agitation vessel so as to beat air into the liquid, and a wall between the agitation vessel and the spitzkasten having a wide communication orifice below the level of the liquid in both vessels, said agitation vessel adapted to discharge substantially directly into the spitzkasten.

2. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, the combination of, an agitation vessel, a spitzkasten contiguous thereto, said vessel and spitzkasten adapted to contain circuit liquid, means for agitating the contents of the agitation vessel so as to beat air into the liquid, a wall between the agitation vessel and the spitzkasten having a wide communication orifice below the level of the liquid in both vessels, and an inclined guide plate in the spitzkasten extending from below the orifice upward toward the surface of the liquid to direct the stream of mineral particles and air bubbles toward the surface of the liquid.

3. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, the combination of, an agitation vessel, a spitzkasten contiguous thereto, said vessel and spitzkasten adapted to contain circuit liquid, means for feeding ore into the agitation vessel, means for feeding circuit liquid into the agitation vessel, a rotary agitator in the agitation vessel arranged to beat air into the liquid, and a wall between the agitation vessel and the spitzkasten having a wide communication orifice below the level of the liquid in both vessels, said agitation vessel adapted to discharge substantially directly into the spitzkasten.

4. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, the combination of, an agitation vessel, a spitzkasten contiguous thereto, said vessel and spitzkasten adapted to contain circuit liquid, means for feeding ore into the agitation vessel, means for feeding circuit liquid into the agitation vessel, a rotary agitator in the agitation vessel arranged to beat air into the liquid, a wall between the agitation vessel and the spitzkasten having a wide communication orifice below the level of the liquid in both vessels, and an inclined guide plate in the spitzkasten extending from below the orifice upward toward the surface of the liquid to direct the stream of mineral particles and air bubbles toward the surface of the liquid.

5. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, the combination of, an agitation

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In testimony whereof I have signed my name to this specificatio
the presence of two subscribing witnesses.

THEODORE JESSE HOOVER.

Witnesses:
H. D. JAMESON.
F. L. RAND.

T. J. HOOVER.

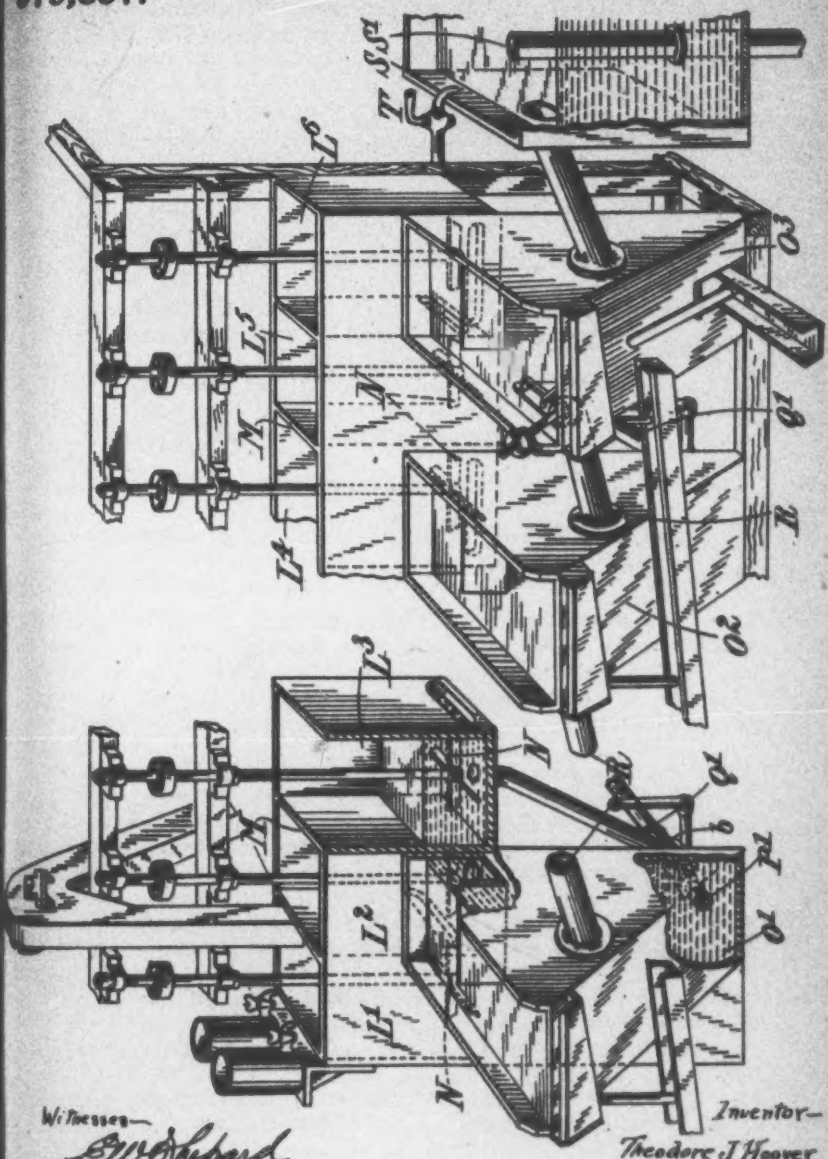
APPARATUS FOR ORE CONCENTRATION.

APPLICATION FILED JULY 14, 1910.

1000

979,857.

Patented Dec. 27, 1910.



Witnesses—
E. W. Shepard
M. J. Holmes

Inventor—
Theodore J. Hoover
By H. J. Shepard
Atty.

No. 259
MINERALS
Separation, Ltd. et al.
Page 1000

999 [COMPLAINANTS' EXHIBIT DRAWING AND SPECIFICATION OF LETTERS PATENT No. 979,857, PATENTED DECEMBER 27, 1910, ISSUED TO E. J. HOOVER.]

(Here follows diagram marked p. 1000.)

1001 United States Patent Office.

THEODORE JESSE HOOVER, of London, England, Assignor to the Minerals Seperation, Limited, of London, England.

979,857, Patented Dec. 27, 1910.

Apparatus for Ore Concentration.

Specification of Letters Patent.

Application Filed July 14, 1910. Serial No. 571,989.

To all whom it may concern:

Be it known that I, Theodore Jesse Hoover, a citizen of the United States of America, residing at London, England, have invented certain new and useful Improvements in Apparatus for Ore Concentration, of which the following is a specification.

This invention relates to improvements in apparatus for ore-concentration.

Several processes are known in which air is beaten into a liquid containing powdered ore in suspension, whereupon the bubbles of air attach themselves to certain particles which are thereby caused to float, while other particles are not so floated.

The object of this invention is to improve the apparatus used in this type of process.

The invention will be best understood with reference to the accompanying drawing which is a diagrammatic illustration of one form of apparatus.

Referring to the drawing several mixing vessels (say six) L^1 L^2 L^3 L^4 L^5 L^6 are placed side by side. These may conveniently be large vats separated by partitions M. Where several vessels are connected together into a group the partitions have openings at the bottom so that the liquid may pass from one vessel to another. At the end of each group however the partitions are complete. Each vessel is provided with a rotatable agitator or stirrer N which is conveniently in the form of several radial blades (curved or straight) radiating from the bottom of a rotatable vertical shaft. Each agitator is carried by a vertical spindle rotated at a high speed by any convenient means.

Crushed ore or similarly divided mineral is fed into the first vessel through any convenient ore feeding device and water is also fed into the vessel.

A small proportion of acid, such as sulfuric acid may be introduced into the water, and a small proportion of one or more other substances which enable metallic sulfids to be floated by air under the conditions specified may be introduced. The liquid containing ore in suspension is vigorously agitated in the vessels. On the lateral wall of the mixing vessel, or of the last mixing vessel of the first group L^2 there is an outlet *a* at the bottom leading directly into a settling apparatus consisting conveniently of a spitzkasten O^1.

The spitzkasten is preferably constructed as shown in the drawing but instead of being connected to the end of the mixing vessel it is connected at the side. The liquid and the sunken material pass out through an outlet P^1 at the bottom of the spitzkasten and a conduit Q^1 connects said outlet with an orifice at the center of the bottom of the next succeeding mixing vessel L^3. The rotating agitator therein performs the function of a centrifugal pump and draws the liquid from the spitzkasten O^1 into said mixing vessel L^3. A suitable valved air inlet *b* controlled by a lever is provided as a part of the conduit Q^1 for the purpose of supplying the necessary air to the liquid after leaving the spitzkasten. The pulp may thus pass through a primary mixing apparatus L^1 L^2 thence through a spitzkasten O^1 into a secondary mixing apparatus L^3 L^4 thence into a second spitzkasten O^2 and through a third mixing apparatus L^5 L^6 and a third spitzkasten O^3. The spitzkasten should be all on one level. At a convenient point, say a few inches below the level of the water in the spitzkasten the spitzkasten are connected together by conduits such as short pipes R. By this means the level of water in the spitzkasten is maintained the same so that exactly the required amount of overflow is constantly maintained in each. The bulk of the circuit liquor passes away with the tailings from the bottom of the last spitzkasten.

In order to determine automatically the level of liquid in the spitzkasten, one of the spitzkasten, conveniently the last, O^3, is connected by a conduit as before with a vessel S of large area (the regulating vessel) placed alongside and filled with liquid, conveniently circuit liquor or water.

One convenient way of keeping a constant level in the regulating vessel is to provide an overflow pipe S^1 the open top of which is at the desired level or a pipe can be so placed that it introduces water into the regulating vessel whenever the level falls below the normal. The regulating vessel may simply be provided with a very small supply of water constantly running in through a tap T at a rate arranged to give the necessary overflow in the spitzkasten or the regulating vessel S may have both an overflow pipe S^1 and an inlet of water through tap T.

Modifications may be made in the details of the invention provided always that the spirit of the invention is not departed
1002 from.

What I claim as my invention and desire to secure by Letters Patent is:

1. Apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising in combination a mixing vessel, an agitator in the mixing vessel, a spitzkasten at the outlet of the mixing vessel, a secondary mixing vessel, a centrifugally acting agitator in said secondary mixing vessel and a connecting conduit between the tailings outlet of the spitzkasten and the zone of the suction influence of the centrifugally acting agitator of said secondary mixing vessel.

2. Apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising a mixing vessel, an agitator in said mixing vessel, a spitzkasten at the outlet of said mixing vessel, a secondary mixing vessel, a connecting conduit between the tailings outlet of the spitzkasten and the center of the bottom of said secondary vessel and a centrifugally acting agitator in said secondary mixing vessel.

3. An apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising in combination a plurality of mixing vessels connected as a group, an agitator in each of said mixing vessels, a spitzkasten at the outlet of said group of mixing vessels a plurality of secondary mixing vessels connected as a group, a centrifugally acting agitator in said secondary mixing vessel, and a connecting conduit between the spitzkasten and the zone of the suction influence of the centrifugally acting agitator.

4. An apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising in combination a first mixing vessel, an agitator in the mixing vessel, a spitzkasten at the outlet of the mixing vessels, a secondary mixing vessel at substantially the same level as the first mixing vessel, a centrifugally acting agitator in said secondary mixing vessel, and a connecting conduit between the tailings outlet of the spitzkasten and the zone of the suction influence of the centrifugally acting agitator in the secondary mixing vessel.

5. An apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising in combination a mixing vessel, a spitzkasten at the outlet of said mixing vessel, a secondary mixing vessel a centrifugally acting agitator therein, and a connecting conduit between the tailings outlet of the spitzkasten and the zone of the suction influence of the centrifugally acting agitator in the secondary mixing vessel, said conduit being provided with an air inlet.

6. An apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising in combination a series of mixing vessels, a centrifugally acting agitator in each, a series of spitzkasten placed respectively at the outlet from the mixing vessels and at the same level with one another, a conduit from the tailings outlet of each spitzkasten to the zone of the suction influence of the centrifugally acting agitator of the next succeeding mixing vessel, and a valve controlled air inlet in said connecting conduit.

7. Apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, comprising in combination a series

of mixing vessels, a centrifugally acting agitator in each, a series of spitzkasten placed respectively at the outlets from the mixing vessels and on the same level with one another, a conduit from the tailings outlet of each spitzkasten to the zone of the suction influence of the centrifugally acting agitator of the next succeeding mixing vessel and a connecting conduit near the top but under the liquid level between each pair of adjacent spitzkasten.

8. Apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, comprising in combination a series of mixing vessels, a centrifugally acting agitator in each, a series of spitzkasten placed respectively at the outlets from the mixing vessels and on the same level with one another, a conduit from the tailings outlet of each spitzkasten to the zone of the suction influence of the centrifugally acting agitator of the next succeeding mixing vessel and a connecting conduit near the top but under the liquid level between each pair of adjacent spitzkasten, a vessel of relatively large area connected by a conduit with one of the spitzkasten and means for maintaining constant the level of the solution therein.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

THEODORE JESSE HOOVER.

Witnesses:
H. D. JAMISON,
N. WILLIAMS.

1003 [COMPLAINANTS' EXHIBIT SPECIFICATION OF LETTERS PATENT No. 488, DATED FEBRUARY 23, 1860, ISSUED TO WILLIAM HAYNES.]

1004 [Third Edition.]

[British Coat of Arms.]

A. D. 1860, 23rd February. No. 488.

Obtaining Metals from Ores.

Letters Patent to William Haynes, of Bank Place, Holywell, in the County of Flint, Metallurgist, for the Invention of "Improvements in Obtaining Metals from Their Ores or Matrices."

Sealed the 17th August, 1860, and Dated the 23rd February, 1860.

Provisional Specification Left by the said William Haynes at the Office of the Commissioners of Patents, with his Petition, on the 23rd February, 1860.

I, William Haynes, of Bank Place, Holywell, in the County of Flint, Metallurgist, do hereby declare the nature of the said Invention for "Improvements in Obtaining Metals from Their Ores or Matrices," to be as follows:—

The nature of the Invention is this:—I first grind the ore to powder and sift it, so as to secure its being of the requisite fineness, and then add what I term my "agent." This is composed of certain substances not soluble in water alone, such as bituminous matter, coal tar from gasworks, and such like; for instance gums or gummy matter, such, for instance, as india-rubber and gutta percha, and fatty or oleaginous matters, and having mixed these together I add one part of this mixture to from five to nine parts of the powdered ore, and then I incorporate the whole together by mixing it in a mixing machine; which being done, I add a sufficient quantity of water to cover the whole bulk, and then pass the same into a triturating machine. Here the separation of the metals from the other portion of the ores or matrices commences, and when the
1005 earthy or foreign matter has separated from the "agent" & metal, I remove such earthy or foreign matter, and replace it by fresh ore or matrix, and repeat this till I find my "agent" will take up no more metal.

To remove the "agent" from the metal, I put the "agent" and metal in an alkaline solution, and in due time the metal is precipitated and can be removed for use, and the agent used again, the alkaline being crystallised, and thus removed from it. The earthy or foreign matter thus freed from metallic admixture will often be valuable for commercial purposes. The details of this Invention admit of variation according to the varied circumstances of operation.

Specification in Pursuance of the Conditions of the Letters Patent Filed by the said William Haynes in the Great Seal Patent Office on the 23rd August, 1860.

To all to whom these presents shall come, I, William Haynes, of Bank Place, Holywell, in the County of Flint, Metallurgist, send greeting:

Whereas Her most Excellent Majesty Queen Victoria, by Her Letters Patent, bearing date the 23rd day of February, in the year of our Lord One thousand eight hundred and sixty, in the twenty-third year of Her reign, did, for Herself, Her heirs and successors, give and grant unto me, the said William Haynes, Her special licence that I, the said William Haynes, my executors, administrators, and assigns, or such others as I, the said William Haynes, my executors, administrators, and assigns, should at any time agree with, and no others, from time to time and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise, and vend within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an Invention for "Improvements in Obtaining Metals from their Ores or Matrices," upon the condition (amongst others) that I, the said William Haynes, my executors or administrators, by an instrument in writing under my, or their or one of their hands and seals, should particularly describe and ascertain the nature of the said Invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent Office within six calendar months next and immediately after the date of the said Letters Patent.

Now know ye, that I, the said William Haynes, do hereby declare the nature of my said Invention, and in what manner the
1866 same is to be performed, to be particularly described and ascertained in and by the following statement, that is to say:—

(1.) The nature of the said Invention, as hath been heretofore described in the Provisional Specification filed on application for the said Letters Patent, consists in this, viz., that having first ground the ore or matrix (or ore and matrix) to powder, and sifted it so as to secure its being of the requisite fineness, I add thereto what I term my "agent," which is composed of certain substances not soluble in water alone, that is, bituminous matter (coal tar from gas works, and such like, for instance), gums or gummy matter (amongst others, gutta percha, india-rubber, for instance), and fatty or oleaginous matter, and having mixed these together I add one part of the mixture thus made to from five to nine parts of the ore, or ore and matrix, and then I incorporate the whole together by agitation of the same in a mixing machine, which being done, I add a sufficient quantity of water to cover the whole bulk, and if thought desirable, pass the same into a triturating machine, when, upon working the said triturating machine, the separation of the metals from the other portions of the ore or matrix commences, although the separation could be effected in the mixing machine

is hereafter described, and when the earthy or foreign matter has separated from the agent and cotton, which often requires no time, I remove such earthy or foreign matter, and replace it by fresh ore or earths, and repeat this till I find my "agent" will take up no more metal. To remove the "agent" from the cotton, I put the agent in an alkaline solution, and in this time the metal is precipitated, and can be removed for use, the alkali, if desired, being neutralized, and thus removed from it. The earthy or foreign matter from the metal, but combined with the alkaline solution, will often be valuable for commercial purposes.

(11.) In order the better to exemplify in what manner the above invention is to be performed or put in practice, I would therefore state, that having an element combined by one or more of the methods, or any suitable method adapted for combining oxide and earthy matter, and passed the same through a sieve or sifting apparatus of 120 meshes to the lineal inch, or thereabouts, I add to the finely divided substance thus obtained, one part, by weight of my "agent," (from 3 to 8 parts of this added are, I consider to be would accord ing to my invention, the variation in the amount of the "agent" in proportion to the quantity of ore being operated by the character of the unfavourable ores, 2 parts, or thereabouts, might be sufficient; while for sulphates and sulphurets, 7 to 8 parts would be required, according to the predominance of sulphur.

207 When I term my "agent" a prepared by uniting together some of the substances mentioned in the scope of this Specification, the particular substances chosen being so chosen to coincide with the known chemical affinity or properties of the particular ore to be operated upon. Thus, to take the instance of tin sulphuret or sulphuret, I make a mixture of 1 part of common salt and 3 or 4 parts of coal tar, the use of the greater quantity than 1 part of coal tar being necessary when the ores is not highly bituminous.

Or, my agent is prepared thus:—1 part, by weight, of tin or tin oxide to from 4 to 8 parts of bituminous substance, or coal, coaltar, the difference between 4 and 8 parts being regulated by the character of the ore, one containing much iron, or forms of iron, requiring the less quantity of those parts. This intermediate form of "agent" is adapted for all ores, except sulphates and sulphurets, or other sulphur-bearing ores.

In preparing my agent I prefer to use such bituminous coal tar, lime, substances and ingredients, here, or many cases as may be liquid or fluid. Or, instead of the above, I form my agent of one part of coal tar to 2 parts of sulphuretted or pyrite powder, but when this agent is applied to tin ore, I require to add many times to the degree of Baumé's hydrometer or less, instead of pure water, which answers for the other forms of my agent, though I prefer many cases to all cases.

Having thus prepared the agent in accordance with the character of the ore about to be treated, I apply it to the finely divided ore as aforesaid by mixing the ore and agent together to a "mixing consistence, that is, to an ordinary brickmaker's clay will, or mixing mixer, or in any other apparatus that will effect the due mechanical

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admixture of the "agent" and the ore; which being done, I add as circumstances may require, either hot, warm, or cold water sufficient to well cover the whole, as herein-before referred to. Whereupon the agitation being still kept up, the agent acts upon the metal, and gradually effects the separation of the metal from the earthy or non-metallic matters of the ore or matrix, or ore and matrix, the earthy matter sinking to the bottom of the water, and the metal being retained by the agent I might here observe that where I speak of ore only, ore or matrix, or ore and matrix, should be understood.

To remove the agent from the metal, I put the agent and metal still in union in a vessel containing an alkaline solution, for instance, a strong solution of caustic soda in water, and in a short time the metal is precipitated to the bottom, and may be removed.

With regard to the agent having the india-rubber or gutta
1008 percha, or both, in its composition, *I* may be that it will be found particularly useful for gold-bearing, quartz, or siliceous ores.

The alkali and agent combined being a saponaceous matter, may be sold to soap makers and others as a commercial product; or this saponaceous solution may be used for the next operation, and so on, and then used for soap. Where the refuse is silica, it will be found available for commercial uses, being in fine powder.

(III.) Having now described the nature of the said Invention, and in what manner the same is to be performed, I declare that I claim the invention of improvements in obtaining metals from their ores and matrices effected by the use of the substances described in the outset (marked I.) of this my Specification, in the manner herein-before set forth.

In witness whereof, I, the said William Haynes, have hereunto set my hand and seal, this 23rd day of August, in the year of our Lord One thousand eight hundred and sixty.

WILLIAM HAYNES. [L. S.]

Signed and sealed in my presence,
F. W. CAMPIN,
Patent Agent, 156 *Strand*.

1009 [Complainants' Exhibit Drawing and Specification of Letters Patent No. 840, Accepted November 23, 1889, Issued to Samuel Bagster Boulton et al.]

1010 [Second Edition.]

[British Coat of Arms.]

No. 840. A. D. 1889.

Date of Application, 16th Jan., 1889.

Complete Specification Left 12th Oct., 1889; Accepted 23rd Nov., 1889.

Provisional Specification.

Improvements in Apparatus for Mixing, Incorporating, or Effecting the Circulation of Liquids and Semi Liquids in Vessels.

We, Samuel Bagster Boulton, Thomas Burt Haywood, and Harold Edwin Boulton, trading under the firm of Burt, Boulton, and Haywood, of 64 Cannon Street, in the City of London, Manufacturers, and Edmond Rich Gabbett, of Old Charlton, Kent, Civil Engineer, do hereby declare the nature of this invention to be as follows:

According to this invention we effect the mixing or incorporation of liquids or semi liquids or the circulation of a liquid within a cauldron or tank by the action of centrifugal force upon part of such liquid or liquids in such manner that a body of liquid is thereby continuously withdrawn from the bottom and delivered at the top, or vice versa, thus producing a continuously ascending or descending column of fluid within the apparatus and a corresponding movement in the contrary direction in the body of liquid outside the apparatus. By thus effecting the mixing or circulation of the liquid entirely by centrifugal action we avoid in a great measure the loss of power due to the friction of mechanical devices moving in the liquid, such as occur in apparatus with helical propelling blades and the like heretofore employed.

The apparatus may be constructed in various ways for operating according to our invention; thus according to one arrangement we employ a conical, conoidal, parabolodial or hemispherical shell immersed in a vertical position in the liquid and having both its upper and lower ends open, the end of larger diameter being situated at top if the circulation is to be in an upward direction through it, and at bottom if a downward circulation is required.

This shell is fixed by suitable arms to a central shaft carried in bearings above the cauldron or vat, so that when more or less rapid rotary motion is imparted to it, and consequently to the body of liquid situated within it, the centrifugal force will act in the well

known manner upon such body of liquid, causing it to rise up on the inner walls of the shell and to flow over the upper edge thereof, into the body of liquid surrounding it, while at the same time fresh liquid will enter the lower end of the shell to replace that which is ejected at top. In place of only a single shell two or more concentric shells may be employed so as to cause a body of liquid to ascend the sides of each shell by centrifugal action, or the body of ascending liquid can be confined within an annular space formed between two concentrical shells, the inner one of which has no opening at the lower end.

When the upper end of the shell is immersed more or less below the level of the liquid, the central part of the upper opening thereof may be covered in by a shield so as to prevent the pressure of the column of liquid above the shell from interfering with the centrifugal action. In order to prevent slip between the inner surface of the shell and the liquid in contact therewith, the shell may be provided with internal longitudinal ribs or vanes.

According to another modification the shell is constructed with the lower end of more or less cylindrical tubular form, while the upper end is widened out to a trumpet-mouth shape, and the central part of this may also be more or less enclosed so that the centrifugal action in ejecting the liquid from the annular orifice thus formed will cause the liquid to be drawn up by the suction produced. Or the entire shell may be of a trumpet mouth shape, and it may be provided with an inner shell as above described with reference to the conical form.

Or, again, the upper end may be formed into two or more hollow horizontal arms communicating at the centre with the vertical tubular part, so that the liquid in being ejected by centrifugal action from the hollow arms will produce a suction in the vertical tube.

1011

According to another modification, instead of employing a continuous shell a number of separate tubular or trough shaped channels may be employed, receding from the central axis as they proceed upward, so that the liquid entering their lower ends is caused to ascend in them by centrifugal action, and flows out at the upper ends.

In all the above described constructions the reverse action may be obtained, that is to say, the liquid may be made to flow downwards through the apparatus by inverting the position of the latter.

In cases where it is preferred to suspend the shaft of the apparatus from bearings above the cauldron or tank, the downward pressure on the bearings due to the weight of the shell may be reduced by making the latter more or less buoyant either by forming it hollow with closed air spaces, or by combining therewith a float of any suitable construction.

The above described invention is applicable with particular advantage in cases where the material to be acted upon requires to be maintained at a comparatively high temperature in order to maintain it in a liquid condition, as in such cases the employment of an

ordinary circulating pump within the vessel or cauldron would be subject to considerable difficulties.

Dated this 16th day of January 1889.

ABEL & IMRAY,
Agents for the Applicants.

Complete Specification.

Improvements in Apparatus for Mixing, Incorporating, or Effecting the Circulation of Liquids and Semi Liquids in Vessels.

We Samuel Bagster Boulton, Thomas Burt Haywood, and Harold Edwin Boulton trading under the firm of Burt Boulton and Hayward of 64 Cannon Street in the City of London Manufacturers and Edmond Rich Gabbett of Old Charlton Kent, Civil Engineer, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

According to this invention we effect the mixing or incorporation of liquids or semi-liquids or the circulation of a liquid within a cauldron or tank, by the action of centrifugal force upon part of such liquid or liquids in such manner that a body of liquid is thereby continuously withdrawn from the bottom and delivered at the top or vice versa, thus producing a continuously ascending or descending column of fluid within the apparatus and a corresponding movement in the contrary direction in the body of liquid outside the apparatus. By thus affecting the mixture or circulation of the liquid entirely by centrifugal action we avoid in a great measure the loss of power due to the friction of mechanical devices moving in the liquid, such as occur in apparatus with helical propelling blades and the like, heretofore employed.

The apparatus may be constructed in various ways for operating according to our invention, thus according to one arrangement we employ a shell of a conical, conoidal, paraboloidal, hemispherical or trumpet mouthed shape fitted if necessary with internal ribs and immersed in a vertical position in the liquid, and having both its upper and lower ends open, the end of large diameter being situated at top if the circulation is to be in an upward direction through it, and at bottom if a downward circulation is required. The shell is fixed by suitable arms to a central strap carried in bearings above the cauldron or vat, so that when more or less rapid rotary motion is imparted to it and consequently to the body of liquid situated within it, the centrifugal force will act in the well known manner upon such body of liquid causing it to rise up on the inner wall of the shell and to flow over the upper edge then into the body
1612 of liquid surrounding it, while at the same time fresh liquid will enter the lower end of the shell to replace that which is ejected at top.

Holes or openings may be made in the shell or tubes at various heights to assist the distribution of the inner column of liquid or semi liquid, through the outer body or the shell may have recipro-

cating motion vertical or horizontal given to it or it may be made to travel around a centre for the same purpose.

Fig. 1. of the accompanying drawings shews a vertical section of one form of the above described apparatus, and Fig. 2 shews a plan.

A is a conical shell having interval ribs A^1 and mounted on a shaft B by which it is suspended within the vessel or tank C containing the liquid to be acted upon, the shaft being carried at its upper end by a bracket D and guided by a bush or stuffing box E on the cover of the vessel C.

Assuming this vessel to be charged with liquid to the level indicated and the shell A to be rotated by suitable gearing such as indicated at F then the body of liquid within the shell being carried round with the same by means of the ribs A^1, the centrifugal force will cause the liquid to rise along the inclined inner surface of the shell and to be ejected into the surrounding liquid when arriving at the upper edge thereof while at the same time the pressure of the surrounding column of liquid in the vessel C, will cause fresh quantities of liquid to enter the lower end of the shell A to make good the quantity discharged at the top. Thus a continuous circulation and consequent mixing of the liquid will be effected as indicated by the arrows.

To prevent the carrying round of the body of liquid in the vessel C by its frictional contact with the outer surface of the shell A, the vessel may be provided with projecting ribs C^1 as shewn, this is however not absolutely necessary and such rotation of the liquid may to some extent be prevented by making the vessel C rectangular, instead of circular as shewn, or by arranging a set of two or more revolving shells such as A in the vessel, either grouped round a central driving shaft or arranged in a row. Also instead of rotating the shell or shells A continuously in one and the same direction they may have their direction of rotation reversed after any desired intervals of time. This might be effected by applying two driving pullies carrying respectively an open and a crossed strap which are shifted alternately on to a loose pulley, as is well understood.

The circulation of the liquid can also be made to take place in the contrary direction to that described by inverting the position of the shell A so that the centrifugal action will cause the liquid within it to travel in a downward direction.

The shell A may also, if desired have an oscillating motion imparted to it, so as to move continuously or intermittently with its lower end to different parts of the vessel C, and thus cause the liquid to be drawn consecutively from such different parts.

This might be effected by connecting the lower part of the shaft B carrying the shell to the upper part running in fixed bearings by a universal joint, and imparting the described motion to and fro thereto by a crank, cam or excentric and connecting rod or by other suitable means.

The shell A may be made to extend above the level of the liquid, instead of being entirely immersed as indicated.

Figs. 3 to 10 shew diagram sections of various other forms which

may be adopted for the revolving shell. Fig. 3 shews a paraboloidal shape, Fig. 4 a construction with hemispherical lower part and cylindrical upper part, the centrifugal action which drives the fluid upward being confined to the lower part. Fig. 5 shews an arrangement in which there are two or more concentric shells, on each of which a body of liquid will be made to ascend by centrifugal action or there may be only two concentric shells as at Fig. 6 forming a narrow annular space in which the liquid ascends, there being no opening in the inner shell. If the shell has its upper end immersed to a considerable extent below the liquid level, the arrangement shewn at Fig. 7 may be adopted in which the top of the shell A is covered by a shield A^2 leaving a narrow annular orifice at *a* for the issue of the liquid. By this means the pressure of 1013 the column of liquid which would otherwise exist in the centre of the shell, is prevented from interfering with the centrifugal action. Fig. 8 shews a construction in which the lower part of the shell is made cylindrical while the upper part is made trumpet mouthed, the centrifugal action being in this case confined to the upper part or the entire shell might be made of a trumpet mouth shape.

Fig. 9 shews a construction with the lower part A more or less cylindrical and terminating at top in two or more tubular arms A^1 which may be either radial or curved. Fig. 10 shews a construction in which instead of employing a continuous shell two or more separate curved or inclined tubular or trough shaped channels A A are used, open at the upper and lower ends so that in revolving the liquid will be caused by the centrifugal action to rise in the tubes or troughs and be discharged at the upper ends in the same way as with the above described shells.

Such tubes or channels may also be made with a helical curvature relatively to the axis of rotation so as to assist in producing the upward or downward motion of the liquid.

If found advantageous to lessen the weight or load on the bearings of the shaft by which the shell is revolved, this can be effected by having an air tight chamber connected to the shell or shaft; thus for instance the shield A^1 shewn in Fig. 7 being made hollow will by its flotation partly carry the weight of the shell &c. or in the — of Fig. 6 if the inner vessel is covered and rendered air tight, the same purpose will be attained.

Although it is preferred to impart the necessary rotary motion to the shell by gearing as described yet it will be evidence that other means might be employed, such as a turbine fitted on the shaft of the shell and driven by steam or other fluid.

The above described invention is applicable with particular advantage in cases where the material to be acted upon requires to be maintained at a comparatively high temperature in order to maintain it in a liquid condition, as in such cases the employment of an ordinary circulating pump within the vessel or cauldron would be subject to considerable difficulties.

Having now particularly described and ascertained the nature of

this invention and in what manner the same is to be performed we declare that what we claim is:

1. In apparatus for mixing incorporating or effecting the circulation of liquids and semi liquids the use of a vessel shell or tube or combination of vessels shells or tubes partly or wholly immersed in the liquid and having its or their upper and lower ends open, such vessel shell or tube being so formed as when rotated upon its vertical axis it will cause the liquid to rise or descend in the same by centrifugal action and to be discharged at the upper or lower end substantially as herein described.

2. In apparatus for mixing incorporating or effecting the circulation of liquids, and semi liquids, the combination with the tank or cauldron C of a shell A of conical conoidal or equivalent shape with internal ribs or projections A^1 and carried by a vertical axis B driven by suitable gearing so as to cause the liquid in the tank or cauldron to ascend in the shell by centrifugal action and to be discharged into the tank at the upper end while at the same time fresh liquid is made to enter at the lower end, substantially as herein described with reference to Figs. 1 and 2 of the accompanying Drawings.

3. In apparatus for mixing incorporating or effecting the circulation of liquids and semi liquids the use of tubular or trough with arms A^1 carried by a vertical revolving axis and partly or wholly immersed in the liquid so that by the centrifugal action of the arms, A^1 the liquid is drawn up through the tubular shell A and expelled through the arms A^1 substantially as described with reference to Fig. 9.

4. In apparatus for mixing incorporating or effecting the circulation of liquids and semi liquids the use of tubular or trough shaped arms A curved by a vertical revolving axis and partly or wholly immersed in the liquid so that by the centrifugal
1014 action of the arms the liquid is caused to rise through them and to be ejected through the upper ends thereof, substantially as herein described with reference to Fig. 10.

Dated this 11th day of October 1889.

ABEL & IMRAY,
Agents for the Applicants.

(Here follows diagram marked p. 1015.)

Fig. 1.

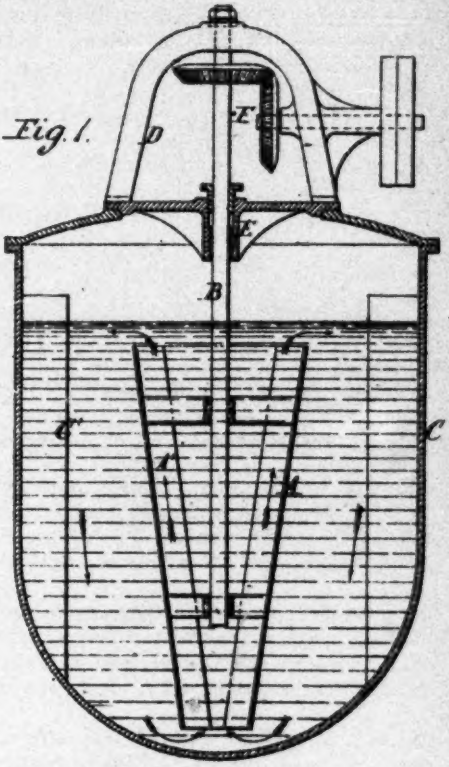
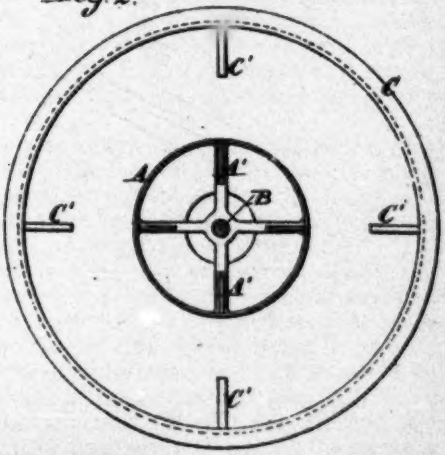


Fig. 2.



[This Drawing is a reproduction of the Original on a reduced scale]

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Separation, Ltd. et al.
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HYDE.
Page 1015
SHEETS)
SHEET 2.

Fig. 3.

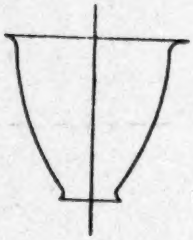


Fig. 4.

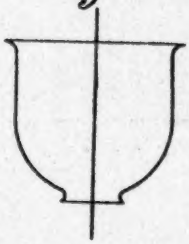


Fig. 5.

Fig. 6.

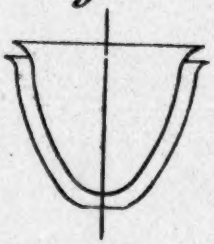


Fig. 7.

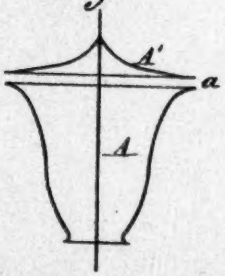


Fig. 8.

Fig. 9.

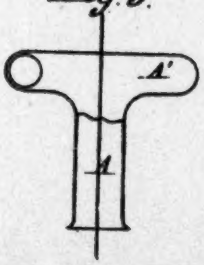
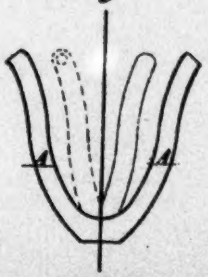


Fig. 10.



1016 & 1017 [COMPLAINANTS' EXHIBIT SPECIFICATION AND DRAWING OF LETTERS PATENT No. 7803, ACCEPTED JANUARY 18, 1903, ISSUED TO HENRY LIVINGSTONE SULMAN ET AL.]

1018 [Second Edition.]

[British Coat of Arms.]

No. 7803. A. D. 1905.

Date of Application, 12th Apr., 1905.

Complete Specification Left 3rd June, 1905; Accepted 18th Jan., 1906.

Provisional Specification.

"Improvements in or Relating to Ore Concentration."

We, Henry Livingstone Sulman, Metallurgist, of 44 London Wall, Hugh Fitzalis Kirkpatrick Picard, Metallurgist, of 44 London Wall, and John Ballot, Merchant, of 62 London Wall, all of the City of London, do hereby declare the nature of this invention to be as follows—

This invention relates to improvements in the concentration of ores, the object being to separate metalliferous matter, graphite and the like from gangue, by means of oils, fatty acids or other substances which have a preferential affinity for metalliferous matter over gangue.

In the process described in the Specification of British Letters Patent No. 18589 of 1903 granted to A. E. Cattermole, an amount of oil varying from 4% to 6% of the weight of metalliferous matter present is agitated with an ore pulp so as to form granules which can be separated from the gangue. In the Specification of British Patent No. 17109 of 1903 granted to A. E. Cattermole and others, a similar method of separation is employed, oleic acid being produced in situ in the ore pulp.

We have found that if the proportion of oily substance be considerably reduced, say to a small fraction of 1% on the ore, granulation ceases to take place and on vigorous agitation, there is a tendency for a part of the oil-coated metalliferous matter to rise to the surface of the pulp in the form of a froth or scum.

This tendency is dependent on a number of factors. Thus, the water in which the oiling is effected is preferably slightly acidified by adding say a fraction of 1% up to 1%, of sulphuric acid or other mineral acid or acid salt, the effect of this acidity being to prevent gangue from being coated with oily substance, or in other words, to render the selective action of the oil more marked; but it is to be understood that the object of using acid in the pulp according to this invention is not to bring about the generation of gas for the purpose

of flotation thereby, and the proportion of acid used is insufficient to cause chemical action on the metalliferous minerals present.

Again, we have discovered that the tendency for the oily substance to disseminate through the pulp and the rapidity with which the metalliferous matter becomes coated is increased if the pulp is warmed.

The formation of froth is assisted by the fine pulverisation of the ore and we find that the slime mineral most readily generates scum and rises to the surface while larger particles have less tendency to be included in the froth.

The proportion of mineral which floats in the form of froth varies considerably with different ores and with different oily substances, and before utilising the facts above mentioned in the concentration of any particular ore a simple preliminary test is necessary to determine which oily substance yields the proportion of froth or scum desired.

The following is an example of the application of this invention to the concentration of a particular ore.

An ore containing ferruginous blende, galena, and gangue consisting of quartz, rhodonite, and garnet, is finely powdered and mixed with water containing a fraction of 1% or up to 1% of a mineral acid or acid salt, conveniently sulphuric acid, or mine or other waters containing ferric sulphate. To this is added a very small pro-
1019 portion of oleic acid (say, from 0.02% to 0.5% on the weight of ore), the mixture is warmed say to 30° to 40° C. and is agitated in a cone mixer or the like, as in the processes previously cited, for about 2½ to 10 minutes, until the oleic acid has been brought into efficient contact with all the mineral particles in the pulp.

When agitation is stopped a large proportion of the mineral present rises to the surface in the form of a froth or scum which has derived its power of flotation mainly from the inclusion of air bubbles introduced into the mass by the agitation, such bubbles or air films adhering only to the mineral particles which are coated with oleic acid. The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1% of the ore, but this proportion has been found suitable and economical.

If the ore were crushed to 90 mesh to the linear inch (half of which ore will pass through 150 mesh sieve) the froth may contain about 70% to 80% of the metalliferous matter present in the ore. This froth is removed from the pulp by spitzkast, upcast, skimming, draining or otherwise and is caused to subside; the coated metalliferous matter is separated from the liquid and treated with an alkali which removes the oleic acid in the form of a soap.

If desired, the oleic acid used in the first instance may be produced in situ in the pulp by decomposing a dilute soap solution with mineral acid as described in the British Patent No. 17109 of 1903 cited above.

The metalliferous matter which did not form part of the froth (generally the larger particles) remains in admixture with the

gangue in the pulp. To recover this, the pulp is distributed in a thin layer on a shaking table, convex buddle or the like, whereon the mineral is exposed to a free air surface, which exposure may be increased by the application of an air blast or air jets or the like, and thereafter brought on to the edge or surface of liquid whereby the metalliferous matter floats and is separated from the gangue which sinks as described in the Specification of our British Patent Application No. 29374 of 1904.

The proportion of mineral recovered in the froth and that recovered by table flotation may be considerably varied but generally speaking the froth will separate the slime mineral while the larger particles are recovered by the latter method.

Dated this 12th day of April, 1905.

BOULT, WADE & KILBURN,
Agents for the Applicants.

Complete Specification.

Improvements in or Relating to Ore Concentration.

We, Henry Livingstone Sulman, Metallurgist, of 44, London Wall, Hugh Fitzalis Kirkpatrick Picard, Metallurgist, of 44, London Wall, and John Ballot, Merchant, of 62, London Wall, all of the City of London, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to improvements in the concentration of ores, the object being to separate metalliferous matter, graphite and the like from gangue, by means of oils, fatty acids or other substances which have a preferential affinity for metalliferous matter over gangue.

In the process described in the previous British Patent No. 18589 of 1903, granted to A. E. Cattermole, an amount of oil varying from 4% to 6% of the weight of metalliferous matter present is agitated with an ore pulp so as to form granules which can be separated from the gangue. In the previous British Patent No. 17109 of 1903, granted to A. E. Cattermole and others, a similar method of separation is employed, oleic acid being produced in situ in the ore pulp.

We have found that if the proportion of oily substance be considerably reduced, say to a fraction of 1% on the ore, granulation ceases to take place and after vigorous agitation, there is a tendency for a part of the oil-coated metalliferous matter to rise to the surface of the pulp in the form of a froth or scum.

This tendency is dependent on a number of factors. Thus, the water in which the oiling is effected is preferably slightly acidified by adding say a fraction of 1% up to 1%, of sulphuric acid or other mineral acid or acid salt, the effect of this acidity being to prevent gangue from being coated with oily substance, or in other words, to render the selective action of the oil more marked; but it is to be understood that the object of using acid in the pulp according to

this invention is not to bring about the generation of gas for the purpose of flotation thereby, and the proportion of acid used is insufficient to cause chemical action on the metalliferous minerals present.

Again, we have discovered that the tendency for the oily substance to disseminate through the pulp and the rapidity with which the metalliferous matter becomes coated is increased if the pulp is warmed.

The formation of froth is assisted by the fine pulverization of the ore and we find that slime mineral most readily generates scum and rises to the surface while larger particles have less tendency to be included in the froth.

The proportion of mineral which floats in the form of froth varies considerably with different ores and with different oily substances, and before utilising the facts above mentioned in the concentration of any particular ore a simple preliminary test is necessary to determine which oily substance yields the proportion of froth or scum desired.

The following is an example of the application of this invention to the concentration of a particular ore.

An ore containing ferruginous blende, galena, and gangue, consisting of quartz, rhodonite, and garnet, is finely powdered and mixed with water containing a fraction of 1% or up to 1% of a mineral acid or acid salt, conveniently sulphuric acid, or mine or other waters containing ferric sulphate. To this is added a very small proportion of oleic acid or petrol, or other suitable oil (say, from 0.02% to 0.5% on the weight of ore), the mixture is warmed say to 30° to 40° C. and is briskly agitated in a cone mixer or the like, as in the processes previously cited, for about 2½ to 10 minutes, until the oleic acid petrol oil etc. has been brought into efficient contact with all the mineral particles in the pulp.

When agitation is stopped a large proportion of the mineral present rises to the surface in the form of a froth or scum which has derived its power of flotation mainly from the inclusion of air bubbles introduced into the mass by the agitation, such bubbles or air films adhering only to the mineral particles which are coated with oleic acid namely the blende and galena. The minimum amount of oleic acid or petrol etc. which can be used to effect the flotation of the mineral in the form of froth may be under 0.1% of the ore, but this proportion has been found suitable and economical.

If the ore were crushed to 90 mesh to the linear inch (half of which ore will pass through 150 mesh sieve) the froth may contain about 70% to 80% of the metalliferous matter present in the ore. This froth is removed from the pulp by spitzkast, upcast, skimming, draining or otherwise; after subsidence the oil-coated metalliferous matter removed as froth is separated from any liquid which may have accompanied it and treated with a dilute solution of caustic alkali which removes the oleic acid petrol oil etc. in the form of a solution of soap.

1021 If desired, the oleic acid used in the first instance may be produced in situ in the pulp by decomposing a dilute soap

solution with mineral acid as described in the British Patent No. 17109 of 1903 cited above. The oleic acid or other fatty acid forming the coating on the metalliferous matter which produces the froth, may give rise to insoluble soaps on the surface of the metalliferous matter if soluble lime, iron or other salts are present in small quantity during the production, or on the breaking down of the froth with alkali; such insoluble soaps are difficult to remove and are capable of adhering to air and causing flotation much the same as the fatty acids do.

The metalliferous matter which did not form part of the froth (generally the larger particles) remains in admixture with the gangue in the pulp. To recover this, the pulp is distributed in a thin layer on a shaking table, convex buddle or the like, whereon the mineral is exposed to a free air surface, which exposure may be increased by the application of air blast or air jets or the like, and thereafter brought on to the edge or surface of liquid whereby the metalliferous matter floats and is separated from the gangue which sinks as described in the Specification of our British Application for Patent No. 29374 of 1904.

The proportion of mineral recovered in the froth and that recovered by table flotation may be considerably varied but generally speaking the froth will separate the slime mineral while the larger particles are recovered by the latter method.

The accompanying drawing is a diagram of one form of apparatus suitable for carrying this invention into practice.

A mixing vessel A (of which there may be any number in series) is provided with a rotatable stirrer B. Crushed ore is fed from a hopper C into the vessel by a band D. A pipe E controlled by a tap E^1 delivers circuit water to the vessel, and oleic acid or other oil is introduced through the pipe F and tap F^1. The outer cock G from the vessel A communicates through a swan-neck pipe H with the froth separating apparatus.

In passing from the frothing apparatus A to the spitzkasten (say between O and K^1) the pulp may if desired be run in a thin layer over a smooth slightly inclined plane and may be submitted to the action of a series of air jets in order to increase the amount of floating metalliferous matter to a maximum.

The froth separating apparatus comprises several (say three) pointed boxes J^1, J^2, J^3 which open at the top into a horizontal channel consisting of side walls K. The channel has a narrow inlet K^1 and spreads out to a wide outlet K^2. The pointed boxes J^1, J^2, J^3 have full-way cocks L^1, L^2, L^3, at the bottom leading to swan-neck discharge pipes M^1, M^2, M^3. An up-current of water may be led in at the bottom of each box through a tap N^1, N^2, N^3.

The boxes are all filled with circuit water; the pulp from the vessel A is distributed horizontally from the flat trough O through the inlet K^1. The heavy sands and coarser particles of mineral sink into the first box J^1 from which they are led to a shaking table, convex buddle, or the like to be treated as above described. The middlings or medium sands fall into the box J^2 and if they contain any mineral, may be removed for further treatment by agitation.

The up-current of water from the taps N^1 N^2 prevents the deposition of any slime in these boxes. The fine sands or gangue slimes settle in the last box J^3 from which they are discharged to waste or further treatment.

The slime mineral in the form of froth or scum floats from the liquid and is carried by the stream over the outlet K^2 into a launder P and thence to a filter Q where the metalliferous matter is removed from the circuit water which is returned to the vessel A by a pump R. The circuit water may be brought to the proper temperature by passing it through a heater S having a burner S^1 before admitting the water to the vessel A.

An alternative method for the recovery of any sunk oiled metalliferous matter which may be deposited in the second and third spitzkasten is as follows:—The products suspended in circuit liquor are removed from the spitzkasten and placed in a vessel in
1022 which they are submitted to an additional pressure of air or other gas of from, say, 1 to 2 atmospheres, or over. On relief of such pressure the bubbles of air, or other gas so generated throughout the mass at once sweep to the surface thereof all the metalliferous matter in the form of a froth which can be separated as before.

The nature and arrangement of the apparatus used may be varied without departing from this invention.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

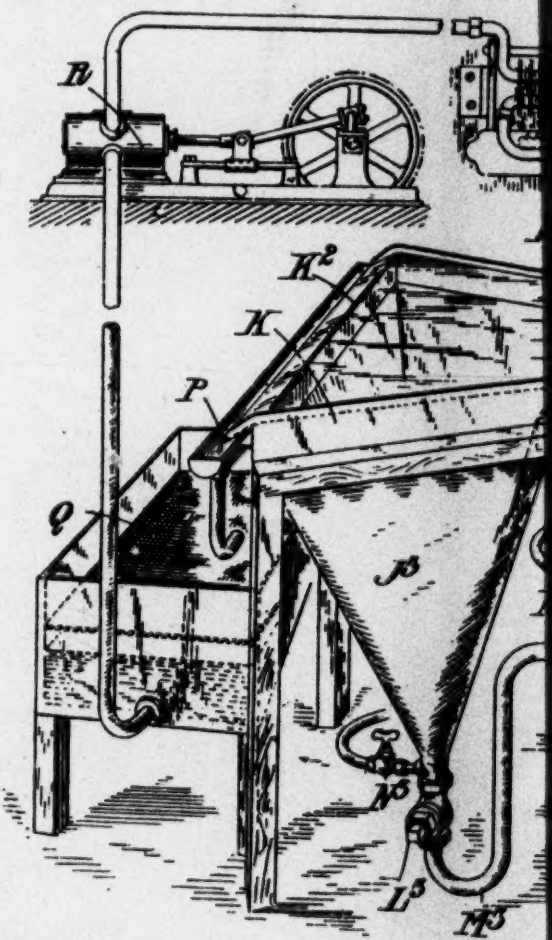
1. The process of concentrating ores in which finely powdered ore suspended in acidified water is mixed with a small proportion of an oily substance such as oleic acid or petrol amounting to a fraction of 1% on the ore, and agitated until the oil-coated metalliferous matter forms into a froth which can be separated from the gangue by flotation.

2. In the process of concentrating ores covered by Claim 1, warming the pulp (say to 30—40° C) to facilitate the oiling of the metalliferous matter.

3. The process of concentrating ores which consists in agitating the finely powdered ore suspended in acidified water with a small proportion of an oily substance such as oleic acid or petrol amounting to a fraction of 1% on the ore, until the slime mineral forms a froth separating the froth by flotation and separating the coarser mineral from the gangue by exposing them alternately to air and water on a shaking table or the like.

4. The process of concentrating ores which consists in agitating the powdered ore suspended in the water with a small proportion of an oily substance such as oleic acid or petrol amounting to a fraction of 1% on the ore, until the oil-coated slime mineral forms a froth, distributing the mixture on the surface of a current of water running over spitzkasten so that the coarser minerals and sands the

(2nd Edition)



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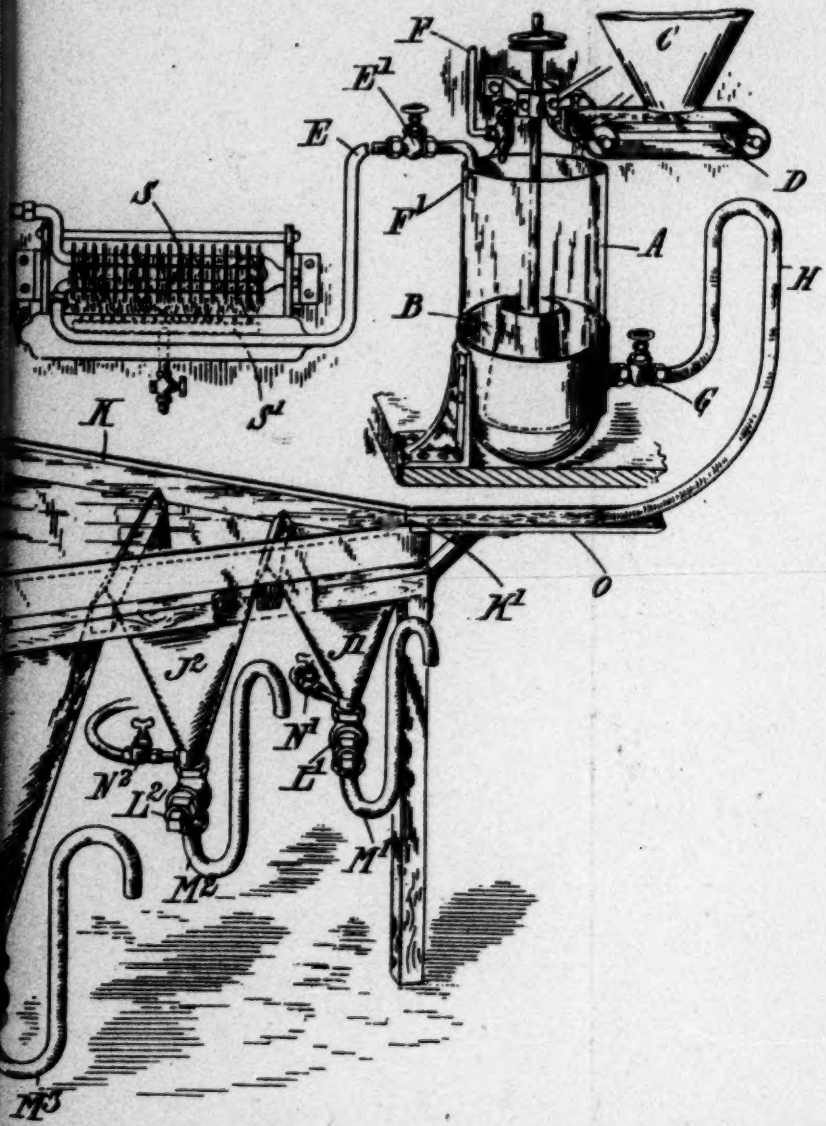
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M2
M3

finer sands and gangue slimes successively deposit out while the froth is floated away by the current and separated by filtration.

Dated this 2nd day of June, 1905.

HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK PICARD.
JOHN BALLOT.
BOULT, WADE & KILBURN,
Agents for the Applicants.

(Here follows diagram marked p. 1023.)

1024 & 1025 [COMPLAINANTS' EXHIBIT SPECIFICATION OF LETTERS PATENT No. 17,328, ACCEPTED OCTOBER 25, 1906, ISSUED TO MINERALS SEPARATION LIMITED.]

1026 [Second Edition.]

[British Coat of Arms.]

No. 17,328. A. D. 1906.

Date of Application, 1st Aug., 1906; Accepted 25th Oct., 1906.

Complete Specification.

"Improvements in or Relating to Ore Concentration."

(A Communication from George Albert Chapman, Metallurgist, of Central Mine, Broken Hill, State of New South Wales, Commonwealth of Australia.)

We, Minerals Separation Limited, of 62, London Wall, in the City of London, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

This invention relates to improvements in the concentration of ores, the object being to separate metalliferous matter, graphite and the like from gangue by means of oils, fatty acids or other substances which have a preferential affinity for metalliferous matter over gangue.

In the process described in the Specification of British Letters Patent No. 7803 of 1905, granted to Sulman, Picard & Ballot, finely powdered ore, suspended in acidified water, is mixed with a small proportion of an oily substance, such as oleic acid, amounting to a fraction of 1% on the ore, and the whole is agitated until the oil-coated metalliferous matter forms into a froth which can be separated from the gangue by flotation. In the arrangement particularly described for carrying the invention into effect, the ore, oil and acidified water were all mixed together in one agitating vessel and any number of such vessels could be employed in series.

In carrying this process into practice where a number of agitating vessels are used in series, it has now been found that particularly effective results can be obtained if the ore is first agitated with acidified water, say in the first vessel and if the oil is subsequently added, say to a second or following vessel.

Where it is desired to heat the pulp to increase the formation of froth, conveniently the heating can take place after the addition of the oil, for example the pulp may be raised to a suitable temperature when it reaches the third or last agitating vessel of the series.

By thus arranging the sequence of operations, it is found that

while the acid strength of the liquor in the first vessel may be say 0·225% acid, the strength in the second vessel is then about 0·05% acid, while in the remaining agitating vessels, in the Spitzkasten feed tanks and other vessels, the acid may be practically or entirely neutralised so that the liquor in circuit as a whole is neutral except at the outset when the ore is introduced.

Having now particularly described and ascertained the nature of the said invention, as communicated to us by our foreign correspondent, and in what manner the same is to be performed, we declare that what we claim is:—

1. The improvement upon the process described in British Patent No. 7803 of 1905, which consists in introducing ore, water and acid into a first agitating vessel and subsequently adding the necessary small proportion of oil or the like in a second or following agitating vessel, substantially as described.

1027 & 1028 2. The improvement upon the process described in British Patent No. 803 of 1905, which consists in introducing ore, water and acid into a first agitating vessel, subsequently adding the necessary small proportion of oil or the like, say in a second or following agitating vessel, and thereafter heating the mixture in another vessel, substantially as described.

3. The complete improvement upon the process described in British Patent No. 7803 of 1905, substantially as described.

Dated this 1st day of August 1906.

BOULT, WADE & TENNANT,
Agents for the Applicant.

1029 [COMPLAINANTS' EXHIBIT SPECIFICATION OF LETTERS PATENT No. 23,870, ACCEPTED NOVEMBER 14, 1914, ISSUED TO MINERALS SEPARATION, LIMITED, ET AL.]

1030 [British Coat of Arms.]

No. 23,870. A. D. 1910.

Date of Application, 14th Oct., 1910.

Complete Specification Left 6th Apr., 1911; Accepted 14th Nov., 1911.

Provisional Specification.

Improvements in or Relating to Ore Concentration.

(Partly Communicated from Henry Lavers, Metallurgist, of Whittaker Street, Broken Hill, New South Wales.)

We, Minerals Separation Limited, and Edward Hoit Nutter, Metallurgist & Mining Engineer, both of 62, London Wall, City of London, do hereby declare the nature of this invention to be as follows:—

This invention is for improvements in or relating to ore concentration by flotation processes and relates more particularly to differential flotation, that is to say, to the separation of different metallic sulphides from one another when flotation processes are used.

The processes described in the previous patents relating to the flotation of metalliferous matter in the form of a froth as for example in the Patents Nos. 7803/1905, 26,852/1908, 28,173/1908 and 2359/1909 have hitherto been used in practice for the separation of metallic sulphides from gangue. It is now found that by varying certain conditions in the flotation processes a separation can be effected between the different metallic sulphides.

It has been observed that when controlling conditions are varied according to this invention the sulphides of various metals have a tendency to float in different ratios to one another. This tendency is dependent upon a number of factors, such as the amount and character of the agitation and/or aeration, the chemical constitution of the solution employed, the degree of dilution, the temperature and the amount and nature of the different frothing agents. The word aeration is used in this specification to mean the supplying of air or other gas or gases. We have found that by varying and modifying these factors and conditions we can obtain effective separations between galena and zinc sulphide as well as between other sulphides and metals.

Thus, according to this invention an ore mixed with water and with agents necessary to bring about the formation of a mineral-bearing froth are agitated together with a certain limited degree of

agitation and/or aeration so as to cause the flotation of a froth containing the sulphides in a different ratio than obtains in the original ore, or in an ordinary froth. This froth may be removed and re-treated under similar differentiating conditions. This re-treatment may be repeated so as to effect a separation of one sulphide from another.

Or again with an ore or product which contains several mixed sulphides, such for example as an ore containing sulphides of copper, lead and zinc, the agitation of the ore pulp may first be effected with the addition merely of a frothing agent such for example as cresol but without mineral acid whereby a froth is obtained containing mainly copper sulphide, which froth may be re-treated under these differentiating conditions. If the remaining pulp containing the unfloated sulphides is now agitated again with the addition of sulphuric acid as well as the frothing agent, a froth may be obtained containing a larger proportion of lead and finally by the addi-
1031 tion of an oily substance such as oleic acid all the remaining sulphides may be floated, the last froth having a preponderating proportion of zinc sulphide. By varying the conditions under which the float is obtained in this way a series of froths are obtained which differ from one another in their constituents and by re-treatment it is possible to obtain froths containing such a preponderance of one metallic sulphide that the concentrate can be supplied direct to the smelter without further separation of its constituents.

This process can be carried out in an apparatus comprising a series of preliminary mixers connected to spitzkasten or separating boxes for the collection of the froth with successive series of mixers to which the froths are supplied for re-treatment.

There are various well known means of concentrating ores or separating mineral particles of different character as by concentrating tables, vanners, jigs, buddles and various other forms of classifying apparatus depending for their effect upon relative differences in size and specific gravity of the particles or relative differences between the particles as regards falling power in water.

However, efficient separation by these means can generally be obtained only in those cases where a somewhat definite size relationship between the constituents of the product treated already exists or has already been produced by preliminary treatment. In other words an apparatus like a concentrating table or vanner will not effectively treat a complicated product like a crushed ore containing perhaps three or four different metalliferous constituents and one or more gangue constituents all in sizes varying from coarse particles to fine slimes; but if the product be submitted to a preliminary treatment which divides the product into fractions which are simpler and more definite in the size relationship of their constituents, the above methods of ore dressing or separation of mineral particles can be effectively employed on the fractions.

In experimenting with the various known flotation processes of ore treatment—that is to say those processes in which the ore mixed with water containing certain agents is agitated or otherwise treated to cause certain constituents to float in the form of a froth or scum—

it is found that when successive froths are produced from a powdered ore (for example by the repeated treatment of the ore pulp under different conditions) the powdered mixtures contained in these successive froths differ widely from the original powdered ore and may differ also from one another as regards the size relationship of their constituents. That is to say if two or more froths are taken from a powdered ore under different conditions, the powdered mixture contained in the first froth may have its constituents in a certain ratio of sizes; the second froth may have its constituents in another ratio of sizes and so on.

The powdered mixture contained in or obtained from each of these froths may now be separately treated on a classifying apparatus such as a concentrating table and an effective separation of the different constituents can be obtained. Such a combination of steps affords means both for the separation of metalliferous matter from gangue and for the separation of different metalliferous ore constituents from one another.

One process therefore of concentrating ores according to this invention consists in treating the crushed ore by a flotation process two or more times under different conditions to obtain froths or scums having the constituents of each in certain ratios of size, and thereafter treating the powdered mixture contained in each froth separately on a classifying apparatus to separate the constituents.

The processes employed to obtain these froths or scums may be any of the well known flotation processes as described for example in Patents Nos. 12,778/02, 29,374/04, 7803/05, 26,852/08, 28,173/08, 2359/09 etcetera.

The classifying apparatus employed may be concentrating tables, vanners, buddles or the like.

1032 The following are examples of applications of this invention:

In the case of an ore containing gangue and sulphides of copper and zinc, if the crushed ore is agitated with water containing a minute proportion of a frothing agent such for example as cresol or eucalyptus oil (but without the use of any acid), the froth produced may contain a proportion of the copper minerals, some comparatively fine zinc and some still finer gangue. If the remaining pulp is heated and a small amount of sulphuric acid is added another float can be taken off which will have a greater proportion of coarser zinc and copper in it than in the first float and in general the zinc will be finer than the copper. If oleic acid is added and another froth taken after the usual agitation the remaining metalliferous constituents will be floated containing much of the coarsest material. The bulk of the gangue will remain unfloated.

These froths could then be treated separately and independently by vanning machines or concentrating tables and a separation as between the different metalliferous constituents present could be better obtained than if the whole metalliferous contents were obtained in one mixed froth and treated together.

In a frothing apparatus of the general type described in the

previous Application No. 6896/1910 the formation of a froth can be effected under different conditions in the different agitators. The various froths can be collected from the different mixers or the different spitzkasten separately and the powdered mixtures obtained from these froths can be treated separately on concentrating tables or the like to obtain an effective separation of the constituents.

In some cases by varying the conditions under which the various froths are formed, the froths obtained will differ from one another both as regards their constituents and as regards their range of size and this invention includes the treatment of a complex ore or product by taking from it two or more froths under different conditions as described so as to obtain froths differing from one another in their character and thereafter re-treating the froths so as to effect a substantial separation of one metalliferous constituent of the ore from another.

Dated this 14th day of October, 1910.

BOULT, WADE & TENNANT,
111/112 *Hatton Garden, London, E. C.,*
Chartered Patent Agents.

Complete Specification.

Improvements in or Relating to Ore Concentration.

We, Minerals Separation Limited, and Edward Hoit Nutter, Metallurgist and Mining Engineer, both of 62, London Wall, City of London, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention is for improvements in or relating to ore concentration by flotation processes and relates more particularly to differential flotation, that is to say, to the separation of different metallic sulphides from one another when flotation processes are used.

The processes described in the previous patents relating to the flotation of metalliferous matter in the form of a froth as for example in the Patents Nos. 7803/1905, 26,852/1908, 28,173/1908 and 2359/1909 have hitherto been used in practice for the separation of metallic sulphides from gangue. It is now found that by varying certain conditions in the flotation processes a separation can be effected between the different metallic sulphides.

1033 It has been observed that when controlling conditions are varied according to this invention the sulphides of various metals have a tendency to float in different ratios to one another. This tendency is dependent upon a number of factors, such as the amount and character of the agitation and/or aeration, the chemical constitution of the solution employed, the degree of dilution, the temperature and the amount and nature of the different frothing agents. The word aeration is used in this specification to mean the supplying of air or other gas or gases. We have found that by varying and modifying these factors and conditions we can obtain effective separations between galena and zinc sulphide as well as between other sulphides and metals.

Thus according to this invention an ore mixed with water and with agents necessary to bring about the formation of a mineral-bearing froth are agitated together with a certain limited degree of agitation and/or aeration so as to cause the flotation of a froth containing the sulphides in a different ratio than obtains in the original ore, or in an ordinary froth. This froth may be removed and re-treated under similar differentiating conditions. This re-treatment may be repeated so as to effect a separation of one sulphide from another.

Or again with an ore or product which contains several mixed sulphides, such for example as an ore containing sulphides of copper, lead and zinc, the agitation of the ore pulp may first be effected with the addition merely of a frothing agent such for example as cresol but without mineral acid whereby a froth is obtained containing mainly copper sulphide, which froth may be re-treated under these differentiating conditions. If the remaining pulp containing the unfloated sulphides is now agitated again with the addition of sulphuric acid as well as the frothing agent, a froth may be obtained containing a larger proportion of lead and finally by the addition of an oily substance such as oleic acid all the remaining sulphides may be floated, the last froth having a preponderating proportion of zinc sulphide. By varying the conditions under which the float is obtained in this way a series of froths are obtained which differ from one another in their constituents and by re-treatment it is possible to obtain froths containing such a preponderance of one metallic sulphide that the concentrate can be supplied direct to the smelter without further separation of its constituents.

This process can be carried out in an apparatus comprising a series of preliminary mixers connected to spitzkasten or separating boxes for the collection of the froth with successive series of mixers to which the froths are supplied for re-treatment.

There are various well known means of concentrating ores or separating mineral particles of different character as by concentrating tables, vanners jigs, buddles and various other forms of classifying apparatus depending for their effect upon relative differences in size and specific gravity of the particles or relative differences between the particles as regards falling power in water.

However, efficient separation by these means can generally be obtained only in those cases where a somewhat definite size relationship between the constituents of the product treated already exists or has already been produced by preliminary treatment. In other words an apparatus like a concentrating table or vanner will not effectively treat a complicated product like a crushed ore containing perhaps three or four different metalliferous constituents and one or more gangue constituents all in sizes varying from coarse particles to fine slimes; but if the product be submitted to a preliminary treatment which divides the product into fractions which are simpler and more definite in the size relationship of their constituents, the above methods of ore dressing or separation of mineral particles can be effectively employed on the fractions.

In experimenting with the various known flotation processes of

treatment—that is to say those processes in which the ore mixed with water containing certain agents is agitated or otherwise treated to cause certain constituents to float in the form of a froth or scum—it is found that when successive froths are produced from a powdered ore (for example by the repeated treatment of the ore pulp under different conditions) the powdered mixtures contained in these successive froths differ widely from the original powdered ore and may differ also from one another as regards the size relationship of their constituents. That is to say if two or more froths are taken from a powdered ore under different conditions, the powdered mixture contained in the first froth may have its constituents in a certain ratio of sizes; the second froth may have its constituents in another ratio of sizes and so on.

The powdered mixture contained in or obtained from each of these froths may now be separately treated on a classifying apparatus such as a concentrating table and an effective separation of the different constituents can be obtained. Such a combination of steps affords means both for the separation of metalliferous matter from gangue and for the separation of different metalliferous ore constituents from one another.

One process therefore of concentrating ores according to this invention consists in treating the crushed ore by a flotation process two or more times under different conditions to obtain froths or scums having the constituents of each in certain ratios of size, and thereafter treating the powdered mixture contained in each froth separately on a classifying apparatus to separate the constituents.

The processes employed to obtain these froths or scums may be any of the well known flotation processes as described for example in Patents Nos. 12,778/02, 29,374/04, 7803/05, 26,852/08, 28,173/08, 2359/09 etcetra.

The classifying apparatus employed may be concentrating tables, vanners, buddles or the like.

The following are examples of applications of this invention:—

In the case of an ore containing gangue and sulphides of copper and zinc, if the crushed ore is agitated with water containing a minute proportion of a frothing agent, such for example as cresol or eucalyptus oil (but without the use of any acid), the froth produced may contain a proportion of the copper minerals, some comparatively fine zinc and some still finer gangue. If the remaining pulp is heated and a small amount of sulphuric acid is added another float can be taken off which will have a greater proportion of coarser zinc and copper in it than in the first float and in general the zinc will be finer than the copper. If oleic acid is added and another froth taken after the usual agitation the remaining metalliferous constituents will be floated containing much of the coarsest material. The bulk of the gangue will remain unfloated.

These froths could then be treated separately and independently by vanning machines or concentrating tables and separation as between the different metalliferous constituents present could be better obtained than if the whole metalliferous contents were obtained in one mixed froth and treated together.

In a frothing apparatus of the general type described in the pre- Application No. 6896/1910 or in the concurrent Application

No. 23,949/1910 the formation of a froth can be effected under different conditions in the different agitators. The various froths can be collected from the different mixers or the different spitzkasten separately and the powdered mixtures obtained from these froths can be treated separately on concentrating tables or the like to obtain an effective separation of the constituents.

In some cases by varying the conditions under which the various froths are formed, the froths obtained will differ from one another both as regards their constituents and as regards their range of size and this invention includes the treatment of a complex ore product by taking from it two or more froths under different conditions as described so as to obtain froths differing from one another in their character and thereafter re-treating the froths so as to effect a substantial separation of one metalliferous constituent of the ore from another.

1035 & 1036 Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, as communicated to us by our foreign correspondent, we declare that what we claim is:

1. The herein described process of concentrating ores which consists in mixing the ore with water and with agents necessary to bring about the formation of a mineral bearing froth, agitating the pulp with a certain limited degree of agitation and/or aeration so as to cause the flotation of a froth containing the sulphides in a different ratio than obtains in the original ore or in an ordinary froth, removing the froth and retreating it under similar differentiating conditions.

2. The herein-described process of concentrating ores which consists in agitating the ore with water containing one mineral frothing agent so as to yield a certain froth containing a fraction of the floatable minerals and removing the froth, agitating the pulp again with the addition of another agent which results in the production of another froth containing a second fraction of the flotable mineral and so on, substantially as described.

3. The herein described process of concentrating ores which consists in agitating the ore pulp first with the addition merely of a mineral-frothing agent but without mineral acid and removing the froth agitating the remaining pulp again with the addition of mineral acid as well as the mineral-frothing agent, removing the froth and thereafter agitating the pulp again with the addition of an oily substance such as oleic acid and removing the froth, each of which froths may be re-treated under differentiating conditions.

4. The herein-described process for concentrating ores which consists in treating the crushed ore by a flotation process two or more times under different conditions to obtain froths or scums having the constituents of each in certain ratios of size, and thereafter treating the powdered mixture contained in each froth separately by a classifying apparatus to separate the constituents.

5. The complete process for concentrating ores substantially as described.

Dated this 6th day of April, 1911.

BOULT, WADE & TENNANT,
111 & 112 *Hatton Garden, London, E. C.*

1037 [COMPLAINANTS' EXHIBIT SPECIFICATION AND DRAWING OF LETTERS PATENT No. 23,949, ACCEPTED NOVEMBER 15, 1911, ISSUED TO EDWARD HOIT NUTTER ET AL.]

1038 [British Coat of Arms.]

No. 23,949. A. D. 1910.

Date of Application, 15th Oct., 1910.

Complete Specification Left 18th Apr., 1911; Accepted 15th Nov., 1911.

Provisional Specification.

Improvements in or Relating to Method and Apparatus for Ore Concentration.

We, Edward Hoit Nutter, Metallurgist and Mining Engineer, and Theodore Jesse Hoover, Metallurgist and Consulting Engineer, and Minerals Separation Limited, all of 62, London Wall, in the City of London, do hereby declare the nature of our invention to be as follows:

This invention is for improvements in or relating to method and apparatus for ore concentration.

Several processes are known in which certain particles are raised to the surface of a liquid containing powdered ore in suspension, by means of bubbles of air or gas that have been caused to attach themselves to these certain particles which are thereby caused to float, while other particles are not so floated. Thus the powdered ore mixed with water containing a mineral-frothing agent may be agitated so as to beat air into the liquid and form a coherent froth by which certain constituents of the ore such as metallic sulphides are floated. One object of this invention is to improve the apparatus used in this type of process, and apparatus constructed in accordance with this invention is applicable for use in any of the well known froth flotation processes of ore concentration.

In apparatus at present in use in which a mineral bearing froth is formed and collected it is customary for the froth to be removed from the main pulp after the froth has reached a free air surface so that if the gaseous bubbles or some of them burst on reaching the free air surface there is a possibility that some of the mineral contents of the froth will fall back into the pulp or circuit liquor and fail to be separated and this does in fact occur.

According to this invention a method of ore concentration by the formation of a mineral bearing froth consists in causing the froth as it is formed to fall over a trap, baffle or wall below the level of the free air surface whereby the froth is collected and removed from the pulp before the bubbles can burst.

An apparatus for concentrating ores by gaseous flotation of cer-

tain mineral particles in liquid according to this invention comprises the combination with an agitating vessel in which the liquid containing a mineral-frothing agent and containing powdered ore in suspension is agitated so as to beat air into it, of a conduit through which the froth passes and a "trap" to catch the froth before the bubbles reach a free air surface whereby the froth is collected and removed from the pulp.

Thus the conduit through which the froth is caused to pass may have a wall, partition, or lip the top of which is below the normal surface of the froth or at any rate below the free air surface of the froth whereby the froth falls over the wall or lip and is trapped before the bubbles in the froth can burst so that the mineral contents of the bubbles which burst are discharged into the trap compartment and not into the pulp. It is possible to arrange that the froth passes directly out of the mixing vessel and over a lip or trap which is below a free air surface and over which the froth passes whereby the froth is collected immediately after it is formed and removed from the pulp before the bubbles can reach the free air surface and burst.

1039 A feature of this invention consists in the combination with two or more mixing vessels of a passage or separate compartment through which the ore pulp travels in passing from one vessel to the other and a froth conduit from said passage or compartment so that the froth is led away and trapped while the pulp is passing from one vessel to another. A practical form of this apparatus comprises a number of mixing and separating vessels substantially on the same level. Passages outside the vessels or separate intermediate compartments connect each vessel with the adjacent vessel and a froth conduit and trap are arranged at each passage or intermediate compartment whereby the froth formed at each stage of the agitation is led away and trapped while the pulp passes through the series of mixing vessels, passages or compartments.

In any of the arrangements described above this invention includes the combination with a first lip which is below the free air surface and over which the whole froth passes into a trap of a second lip over which the more permanent froth passes from the trap into a launder or other colector, and various arrangements may be used for removing the concentrates that sink to the bottom of the trap compartment.

The following is a description by way of example of one form of apparatus embodying this invention:—

Several mixing vessels are placed side by side on the same level. These may conveniently be vats separated by partitions. Each vessel is provided with a rotatable agitator or stirrer carried by a vertical spindle rotated at a high speed by any convenient means.

The first vessel is connected to the second, the second to the third, the third to the fourth and so on by passages and compartments outside the mixing vessels lying along one side of the mixing vessels or between them and on the same level with them. By this arrangement the pulp passes from the first vessel through the connecting passage or compartment to the second vessel and so on, and at the end

of the series the pulp may conveniently be passed into a spitzkasten as described in the previous British Patent No. 4911/1909 for example.

At each connecting passage or compartment there is a froth trap, that is to say, baffles or conduits are so arranged in connection with these passages that the mineral-bearing bubbles in rising are directed into a separate compartment from that through which the main circuit passes before the bubbles reach the free air surface and have a chance to break. Thus, for example, a wall of each connecting passage may be formed by a partition the top or lip of which is below the level of the free air surface of the froth when the apparatus is working. The froth rises in the connecting passage and a roof or cover is provided to lead the froth over the lip or partition before the bubbles get to a free air surface. Outside the lip or partition is a trap compartment into which the mineral-bearing froth falls or passes. The froth reaches a free air surface in this trap compartment and the bubbles which burst deposit the mineral in the trap compartment. The outer wall of the trap compartment may comprise a second lip higher than the first; and the more permanent froth will collect in the trap compartment and flow over the second lip into a launder and in most cases it will be found that the froth passing into the launder will carry the cleanest concentrate.

Any suitable means may be employed for removing the mineral from the trap compartment. If the mineral is not a clean concentrate or if it contains mixed minerals it may be re-treated conveniently in an apparatus similar to the one just described. It will be seen that the apparatus can be made in an extremely compact form as the pulp remains substantially on the same level throughout.

The apparatus affords a solution of many problems. There are many ores which are poor in sulphides, or which do not readily froth or which form a froth which is tender. The tendency in such cases is for the bubbles to break as the froth reaches the surface of the pulp and for part of the mineral to sink back into the pulp. With some frothing agents it is quite possible to get the mineral to the surface but a permanent froth is not usually formed but by the use of the apparatus embodying this invention substantially all the mineral which is floated is collected. With the frothing apparatus at present in use the froth does not have an opportunity of separating until the pulp as a whole has undergone a certain period of agitation. With some frothing agents the normal agitation is too long that is to say mineral-bearing froth formed during the commencement of the agitation is destroyed again before the froth has an opportunity of separating. With the present apparatus however the froth will come off and be trapped immediately after it is formed.

Another important problem was to provide a plant which will lend itself to the separation of the different metalliferous constituents of an ore by differential flotation. In the Patent Application No. 23,870 of 1910 is described a process of obtaining successive mineral bearing froths and by conducting the mixing operation under varying conditions and thereafter treating the different froths again under differentiating conditions.

The apparatus embodying this invention affords ready means for carrying out such a process as the froth may be trapped, re-treated and trapped again exactly at the stages required for differentiating between the different flotable constituents.

The details of the apparatus may be varied without departing from this invention, thus the form of the conduit through which the froth passes away from the pulp may be widely varied as such conduit may be formed by suitably directed baffles, walls, tubes and the like. The method of conveying the mineral from the trap compartment may be by spitzluten, by continuous water flow, by positive conveyor, by automatic valve or otherwise.

Dated this 15th day of October, 1910.

BOULT, WADE & TENNANT,
111/112, *Hatton Garden, London, E. C.,*
Chartered Patent Agents.

Complete Specification.

Improvements in or Relating to Method and Apparatus for Ore Concentration.

We, Edward Hoit Nutter, Metallurgist and Mining Engineer, and Theodore Jesse Hoover, Metallurgist and Consulting Engineer, and Minerals Separation Limited, all of 62, London Wall, in the City of London, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention is for improvements in or relating to a method and apparatus for ore concentration.

Several processes are known in which certain particles are raised to the surface of a liquid containing powdered ore in suspension, by means of bubbles of air or gas that have been caused to attach themselves to these certain particles which are thereby caused to float, while other particles are not so floated. Thus the powdered ore mixed with water containing a mineral-frothing agent may be agitated so as to beat air into the liquid and form a coherent froth by which certain constituents of the ore such as metallic sulphides are floated. One object of this invention is to improve the apparatus used in this type of process, and apparatus constructed in accordance with this invention is applicable for use in any of the well known froth flotation processes of ore concentration.

1041 In apparatus at present in use in which a mineral bearing froth is formed and collected it is customary for the froth to be removed from the main pulp after the froth has reached a free air surface so that if the gaseous bubbles or some of them burst on reaching the free air surface there is a possibility that some of the mineral contents of the froth will fall back into the pulp or circuit liquor and fail to be separated and this does in fact occur.

According to this invention a method of ore concentration by the formation of a mineral bearing froth consists in causing the froth as it is formed to fall over a trap, baffle or wall below the level of the

free air surface whereby the froth is collected and removed from the pulp before the bubbles can burst.

An apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid according to this invention comprises the combination with an agitating vessel in which the liquid containing a mineral-frothing agent and containing powdered ore in suspension is agitated so as to beat air into it, of a conduit through which the froth passes and a "trap" to catch the froth before or as the bubbles reach a free air surface whereby the froth is collected and removed from the pulp.

Thus the conduit through which the froth is caused to pass may have a wall, partition, or lip the top of which is below the normal surface of the froth or at any rate below the free air surface of the froth whereby the froth falls over the wall or lip and is trapped before the bubbles in the froth can burst so that the mineral contents of the bubbles which burst are discharged into the trap compartment and not into the pulp. It is possible to arrange that the froth passes directly out of the mixing vessel and over a lip or trap which is below a free air surface and over which the froth passes whereby the froth is collected immediately after it is formed and removed from the pulp before the bubbles can reach the free air surface and burst.

A feature of this invention consists in the combination with two or more mixing vessels of a passage or separate compartment through which the ore pulp travels in passing from one vessel to the other and a froth conduit from said passage or compartment so that the froth is led away and trapped while the pulp is passing from one vessel to another. A practical form of this apparatus comprises a number of mixing and separating vessels substantially on the same level. Passages outside the vessels or separate intermediate compartments connect each vessel with the adjacent vessel and a froth conduit and trap are arranged at each passage or intermediate compartment whereby the froth formed at each stage of the agitation is led away and trapped while the pulp passes through the series of mixing vessels, passages or compartments. The mixing vessels may be connected together in pairs by orifices in the partitions between them, and the passages outside the vessels may be arranged to connect one vessel of each pair with the adjacent vessel of the next pair, a froth trap being placed at each passage.

In any of the arrangements described above this invention includes the combination with a first lip which is below the free air surface and over which the whole froth passes into a trap of a second lip over which the more permanent froth passes from the trap into a launder or other collector, and various arrangements may be used for removing the concentrates that sink to the bottom of the trap compartment.

In the accompanying drawings which illustrate by way of example one form of apparatus embodying this invention,

Figure 1 is a front elevation partly in section;

Figure 2 is a transverse section, and

Figure 3 is a plan of the apparatus.

Several mixing vessels A are placed side by side on the same level. Each vessel is provided with a rotatable agitator or stirrer A′ carried by a vertical spindle A^2 rotated at a high speed by any con-
1042 venient means. The first vessel is connected with the second, the second to the third, the third to the fourth and so on by passages or compartments B between the mixing vessels and on the same level with them. By this arrangement the pulp passes from the first vessel A through the connecting passage or compartment B to the second vessel A and so on and at the end of the series the pulp may conveniently be passed into a spitzkasten as described in the previous British Patent No. 4911 of 1909 for example.

At each connecting passage or compartment B there is a froth trap, that is to say baffles or conduits are so arranged in connection with these passages that the mineral-bearing bubbles in rising are directed into a separate compartment from that through which the main circuit passes, before the bubbles reach the free air surface and have a chance to break. Thus, for example, the wall of each connecting passage may be formed by a partition D the top or lid D′ of which is below the level of the free air surface of the froth when the apparatus is working.

The froth rises in the connecting passage B and a roof or cover E is provided to lead the froth over the lip or partition D before the bubbles get to a free air surface. Outside the lip or partition is a trap compartment F into which the mineral-bearing froth falls or passes. The froth reaches a free air surface in this trap compartment F and the bubbles which burst deposit the mineral in the trap compartment. The outer wall G of the trap compartment may comprise a second lip G′ higher than the first; and the more permanent froth will collect in the trap compartment F and flow over the second lip G^1 into a launder H and in most cases it will be found that the froth passing into the launder will carry the cleanest concentrate.

Any suitable means may be employed for removing the mineral from the trap compartment. If the mineral is not a clean concentrate or if it contains mixed minerals it may be re-treated conveniently in an apparatus similar to the one just described. It will be seen that the apparatus can be made in an extremely compact form as the pulp remains substantially on the same level, throughout.

The apparatus affords a solution of many problems. There are many ores which are poor in sulphides, or which do not readily froth or which form a froth which is tender. The tendency in such cases is for the bubbles to break as the froth reaches the surface of the pulp and for part of the mineral to sink back into the pulp. With some frothing agents it is quite possible to get the mineral to the surface but a permanent froth is not usually formed but by the use of the apparatus embodying this invention substantially all the mineral which is floated is collected. With the frothing apparatus at present in use the froth does not have an opportunty of separating until the pulp as a whole has undergone a certain period of agitation. With some frothing agents the normal agitation is too long that is to say mineral-bearing froth formed during the commencement of the agitation is destroyed again before the froth has an opportunity of

separating. With the present apparatus however the froth will come off and be trapped immediately after it is formed.

Another important problem was to provide a plant which will lend itself to the separation of the different metalliferous constituents of an ore by differential flotation. In the Patent Application No. 23,870 of 1910 is described a process of obtaining successive mineral bearing froths and by conducting the mixing operation under varying conditions and thereafter treating the different froths again under differentiating conditions.

The apparatus embodying this invention affords ready means for carrying out such a process as the froth may be trapped, re-treated and trapped again exactly at the stages required for differentiating between the different flotable constituents.

The details of the apparatus may be varied without departing from this invention, thus the form of the conduit through
1043 which the froth passes away from the pulp may be widely varied as such conduit may be formed by suitably directed baffles, walls, tubes and the like. The method of conveying the mineral from the trap compartment may be by spitzluten, by continuous water flow, by positive conveyor, by automatic valve or otherwise.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid, the combination with an agitating vessel in which the liquid containing powdered ore in suspension is agitated so as to beat air into it, of a conduit through which the froth passes and a "trap" to catch the froth before or as the bubbles reach the liquid surface whereby the froth is collected and removed from the pulp.

2. A method of ore concentration by the formation of a mineral bearing froth which consists in causing the froth as it is formed to fall over a trap or wall below the level of the free air surface whereby the froth is collected and removed from the pulp before the bubbles can burst.

3. In an apparatus for concentrating ores by gaseous flotation of certain mineral particles in liquid the combination with two mixing vessels of a passage which conveys the ore pulp from one vessel to another and a froth conduit from the passage whereby the froth is led away and trapped substantially as described.

4. A practical form of apparatus of the kind described for concentrating ores by gaseous flotation of certain mineral particles in liquid comprising a number of mixing vessels substantially on the same level connected together in pairs by offices in the partitions between them and passages outside the vessels connecting one vessel of each pair with the adjacent vessel of the next pair and a froth trap at each passage whereby the froth formed at each stage of the agitation is led away and trapped while the pulp passes through the series of mixing vessels.

5. In an apparatus as covered in any of the preceding claims the

combination with a first lip which is below the free air surface and over which the whole froth passes into a trap of a second lip over which the more permanent froth passes into a launder or other collector.

Dated this 18th day of April, 1911.

BOULT, WADE & TENNANT,
111 & 112, *Hatton Garden, London, E. C.,*
Chartered Patent Agents.

(Here follow diagrams marked p. 1044 to 1058.)

[*This Drawing is a reproduction of the Original on a reduced scale.*]

Fig. 1.

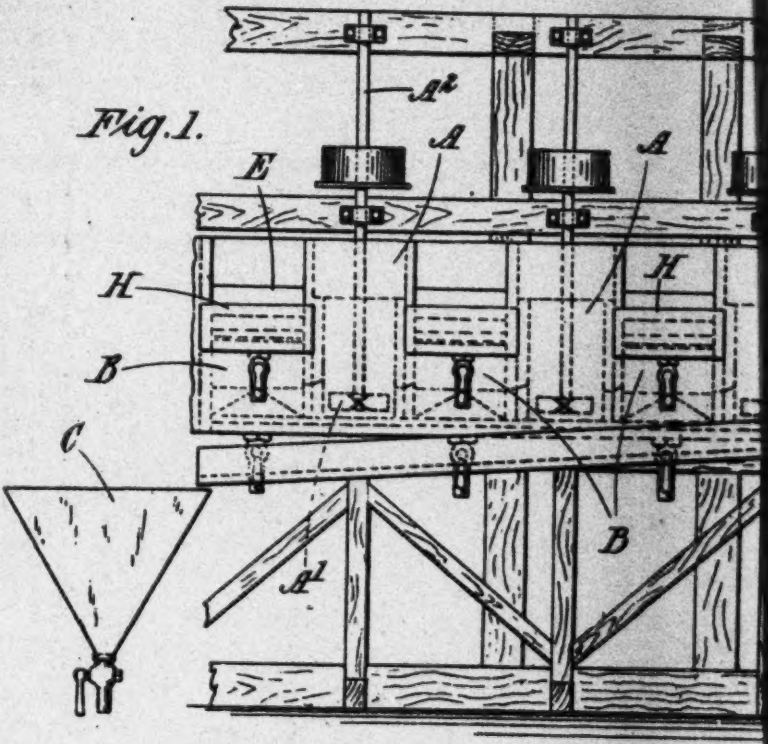
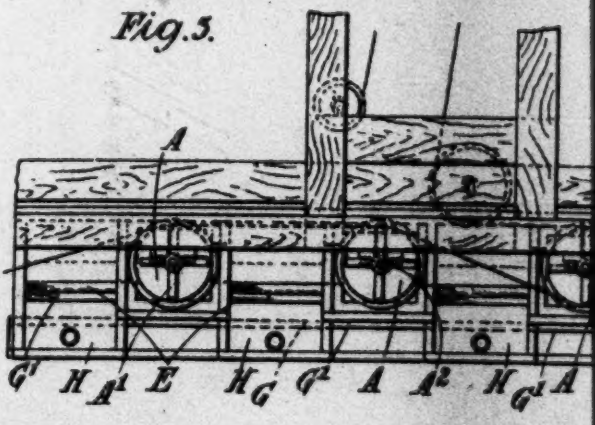
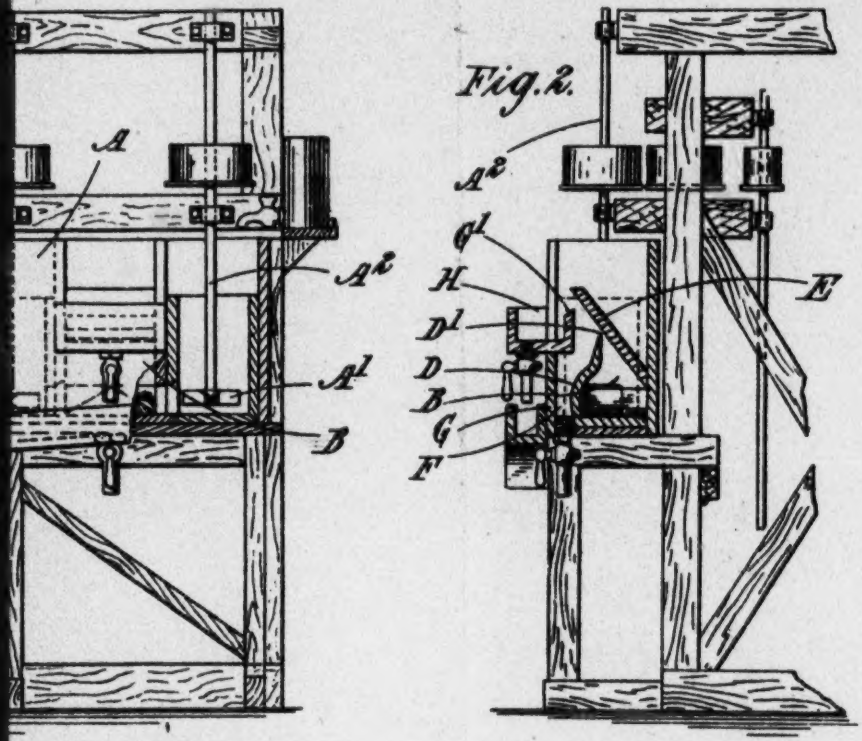
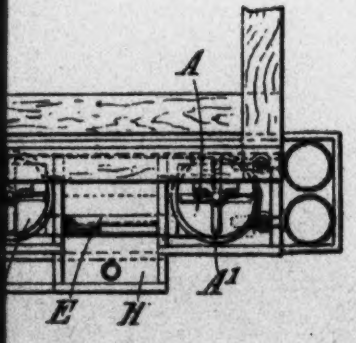


Fig. 3.




A
A²
A¹
B
Fig. 2.
A²
G¹
H
E
D¹
D
B
G
F

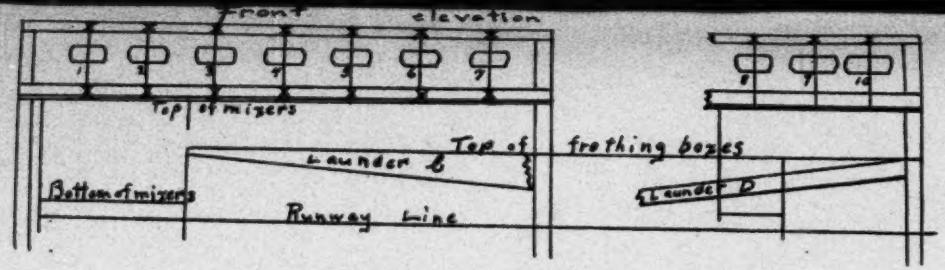

A
A¹
E
H

No. 259
MINERALS
Separation, Ltd. et al. } Page 1045
v.
HYDE.

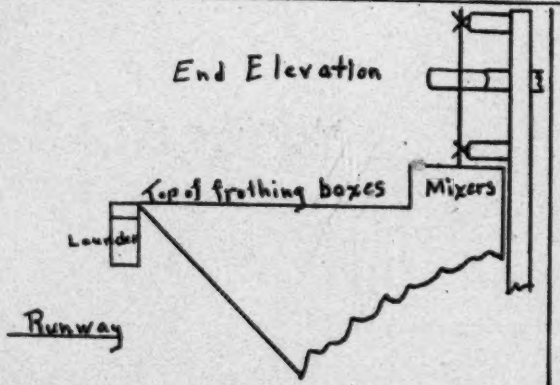
COMPLAINANTS' EXHIBIT, HUTTER DRAWING DEFENDANT'S PLANT (Sheet 1).

Platform
Shop
Bench
Slide door
Running
Jigging
Working
Jigging
Jigging
Jigging

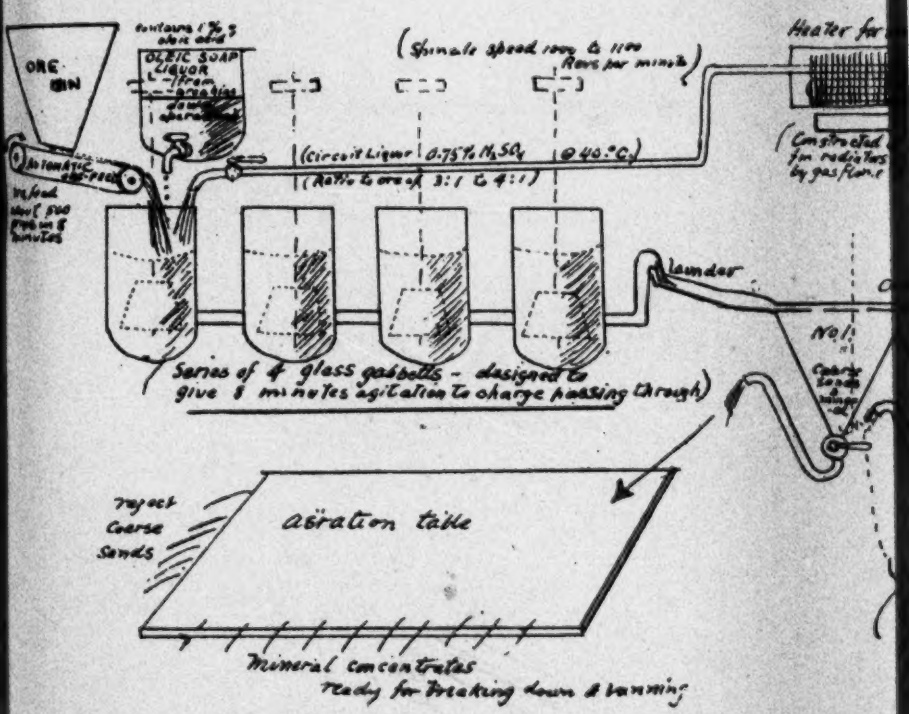
COMPLAINANTS' EXHIBIT, NUTTER DRAWING DEFENDANT'S PLANT (Sheet 2).



Floor Line



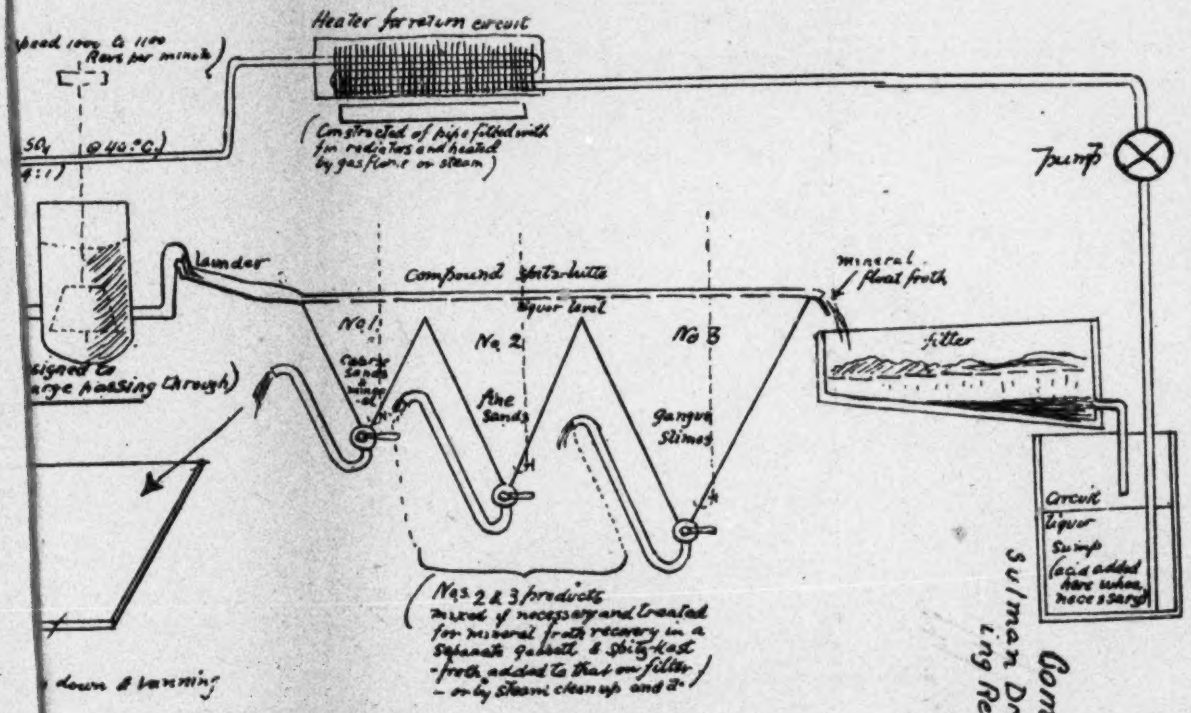
Sketches showing front and end elevations of flotation plant in Basin mill Montana, Ett, nutter. Figures and letters have the same reference value in all sketches. Broken lines indicate the extent of my observations. Framework carrying agitator bearings may be different than shown as I did not observe it closely. Crosses indicate shaft bearings



Copies sent
Geo. A. Chapman
& C.F. Courtney
5/6/05

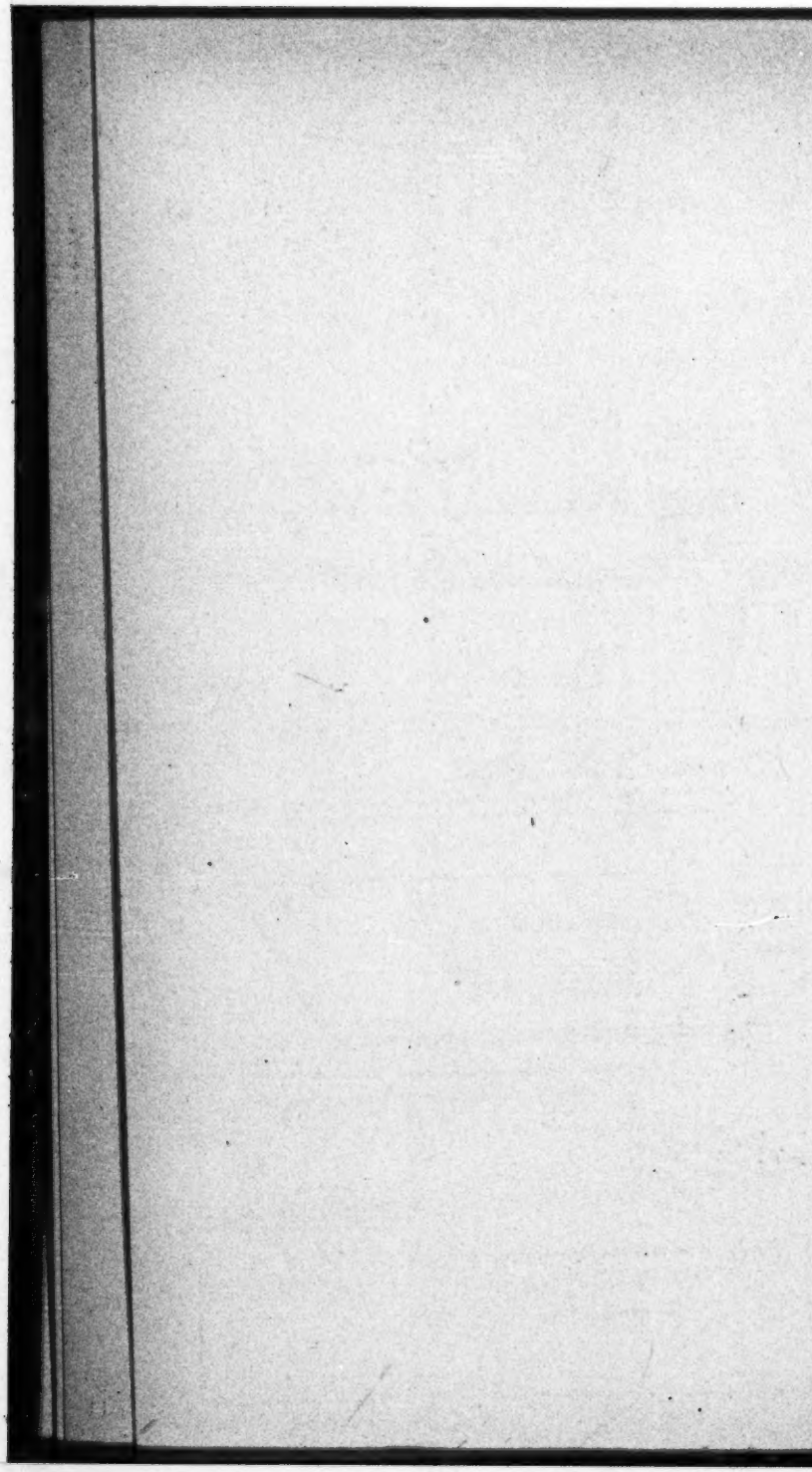
Diagram accompanying
S. & P3 Report 4/5/05

Diagrammatic Sketch
for A.1

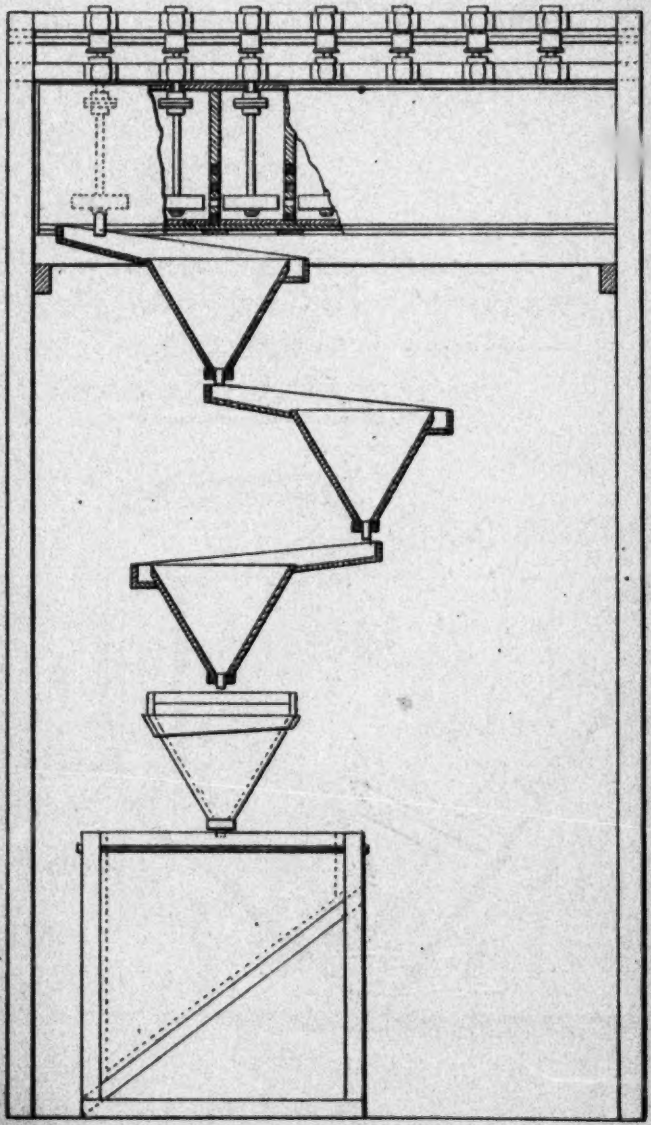


Diagrammatic Sketch of plant arranged for 0.1 - 0.2 % Oleic acid process

Complainants' Exhibit
Sulman Drawing accompanying Report - May 3, 1905.



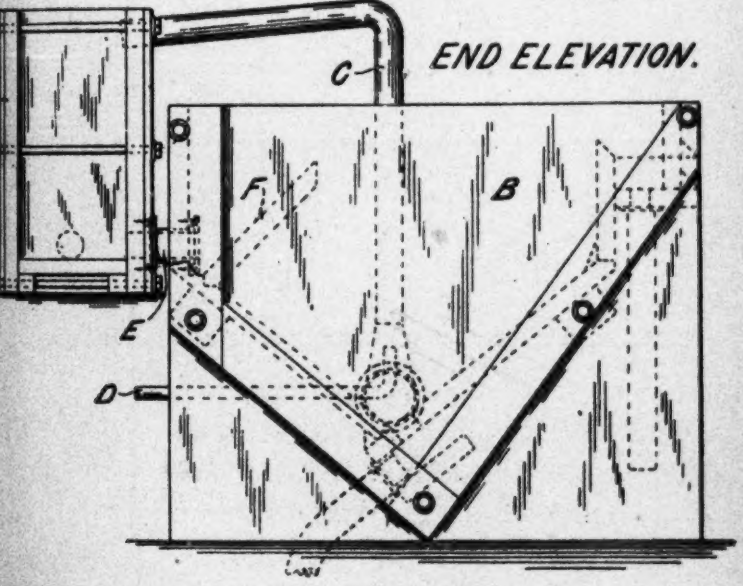
COMPLAINANTS EXHIBIT DRAWING AUSTRALIAN MODEL PLANT



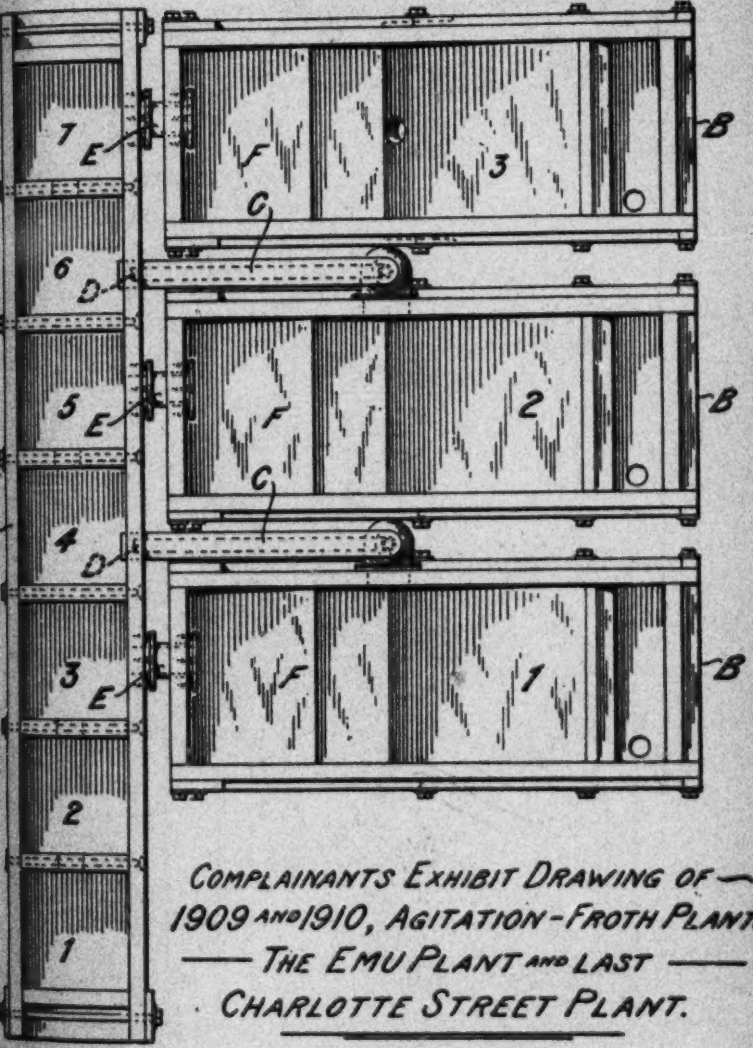
COMPLAINANTS EXHIBIT DRAWING OF
1909 AND 1910 AGITATION-FROTH PLANTS.
— THE EMU PLANT AND LAST —
CHARLOTTE STREET PLANT.

Sheet 1.

END ELEVATION.



PLAN. Sheet. 2.

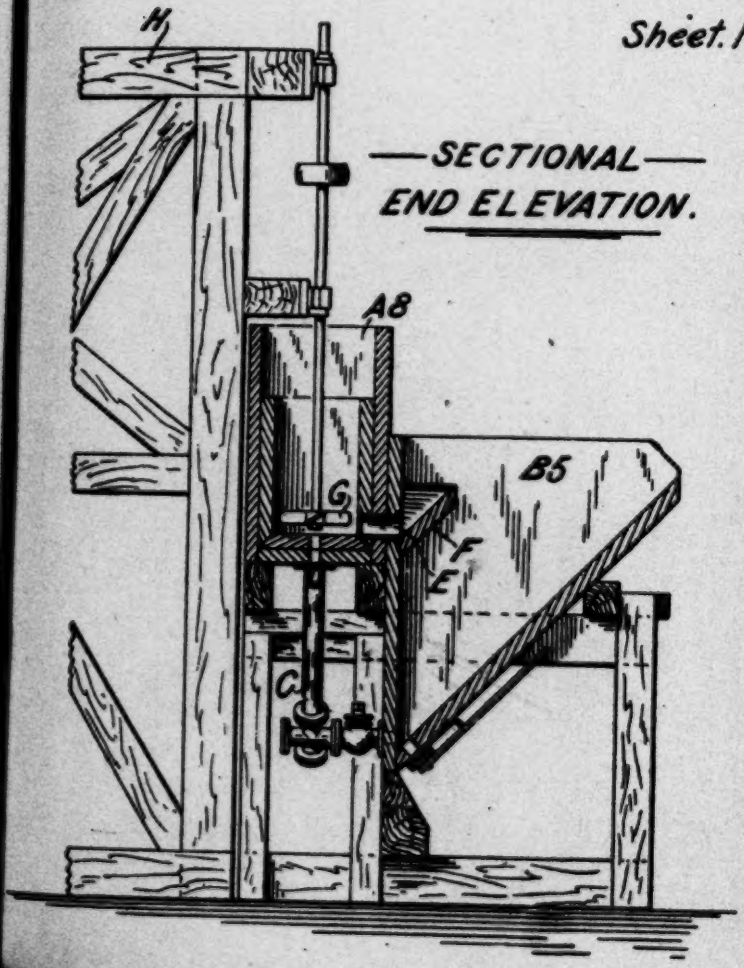


COMPLAINANTS EXHIBIT DRAWING OF—
1909 AND 1910, AGITATION-FROTH PLANTS.
—— THE EMU PLANT AND LAST ——
CHARLOTTE STREET PLANT.

—COMPLAINANTS EXHIBIT—

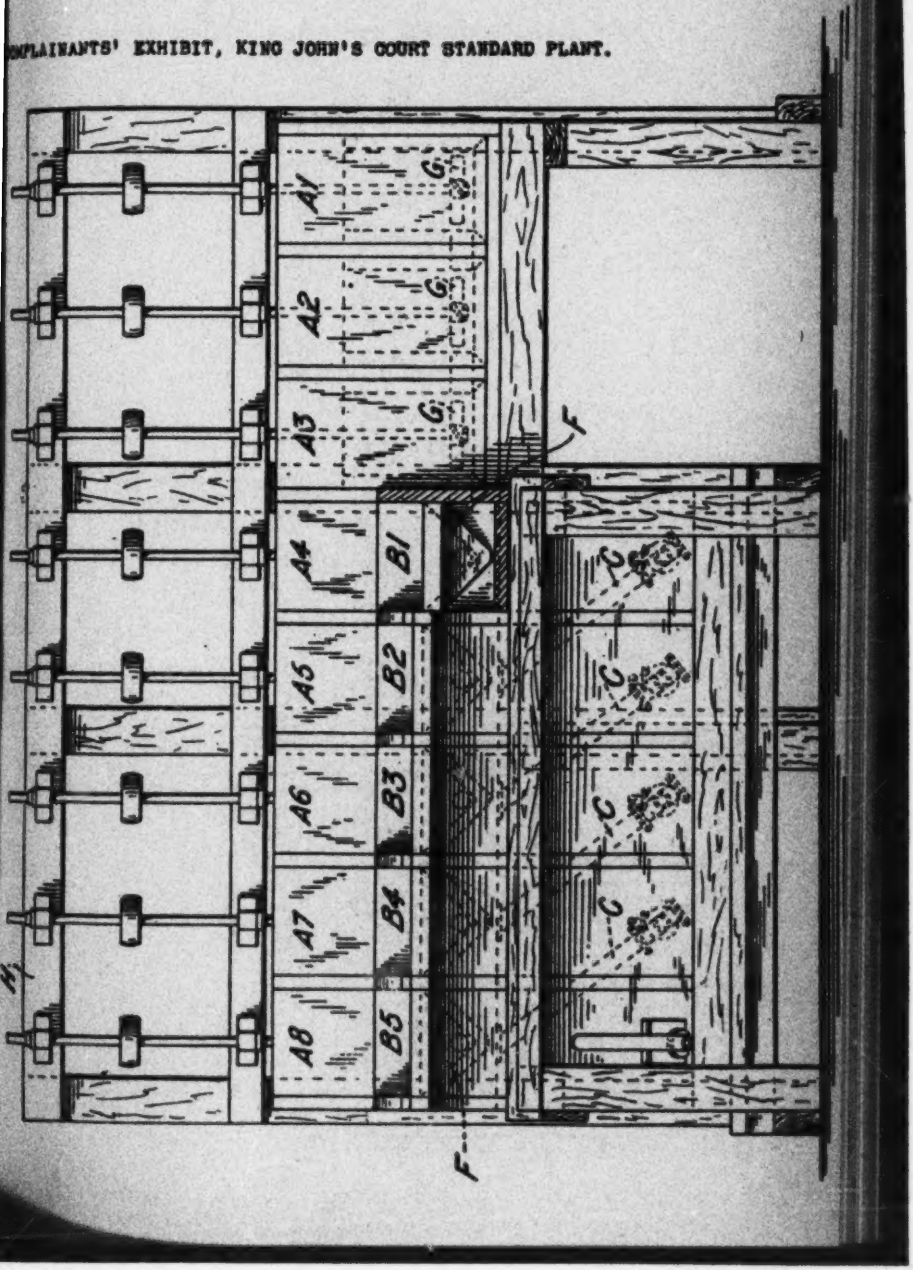
ING JOHN'S COURT STANDARD PLANT.

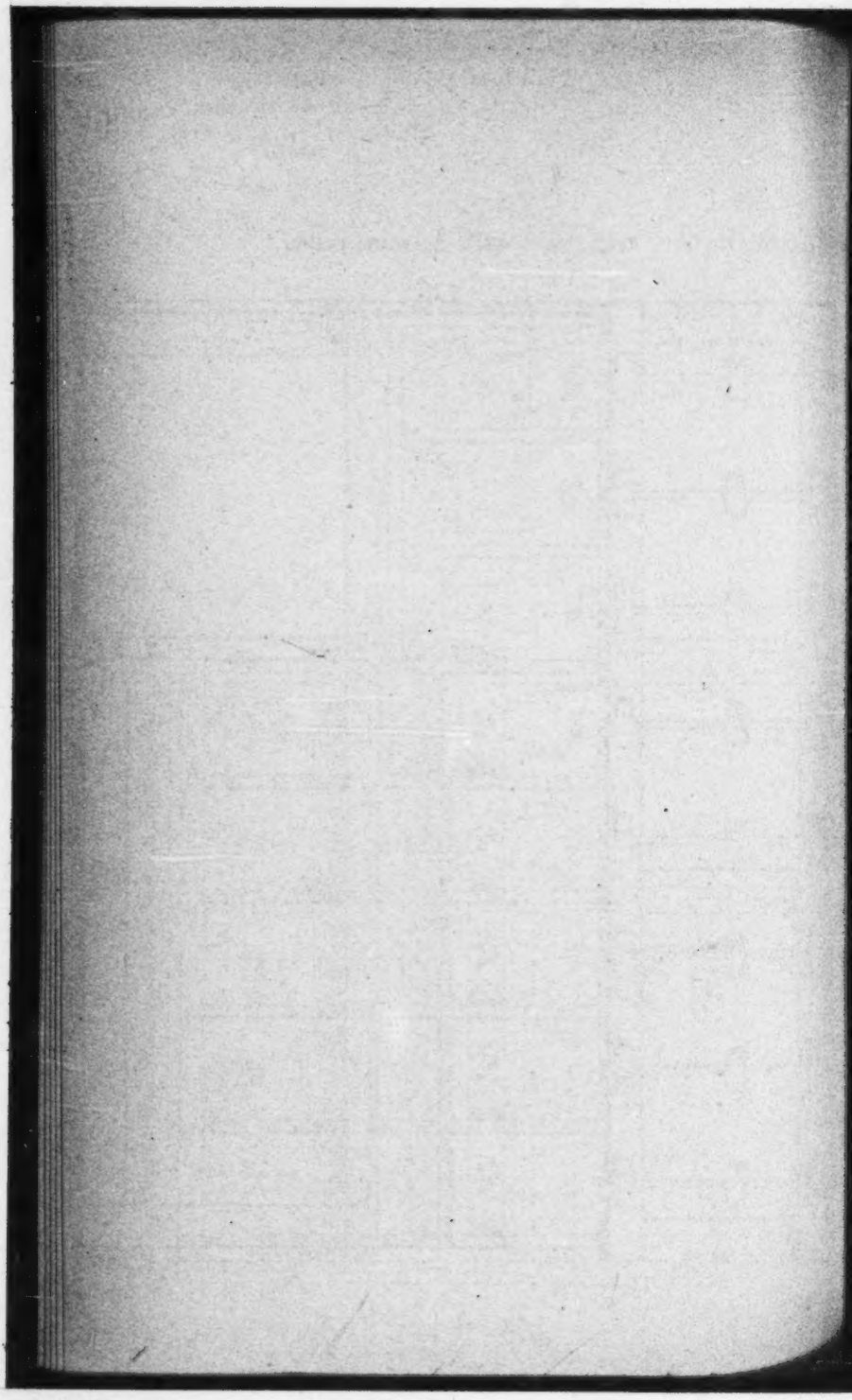
Sheet. 1.



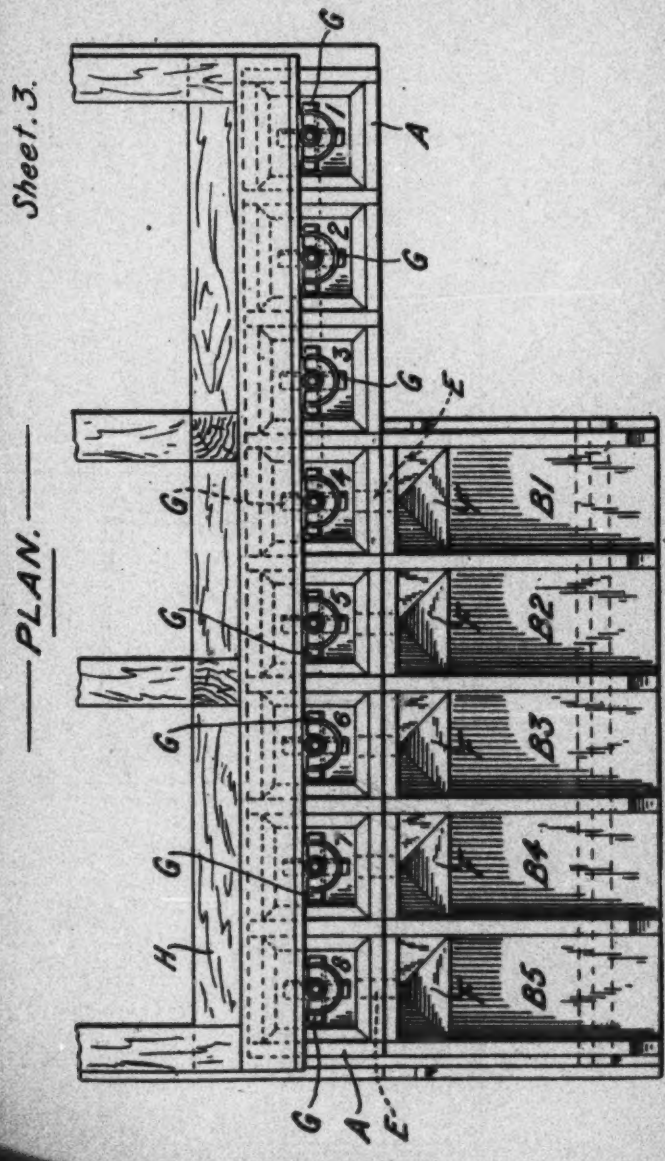
—SECTIONAL—
END ELEVATION.

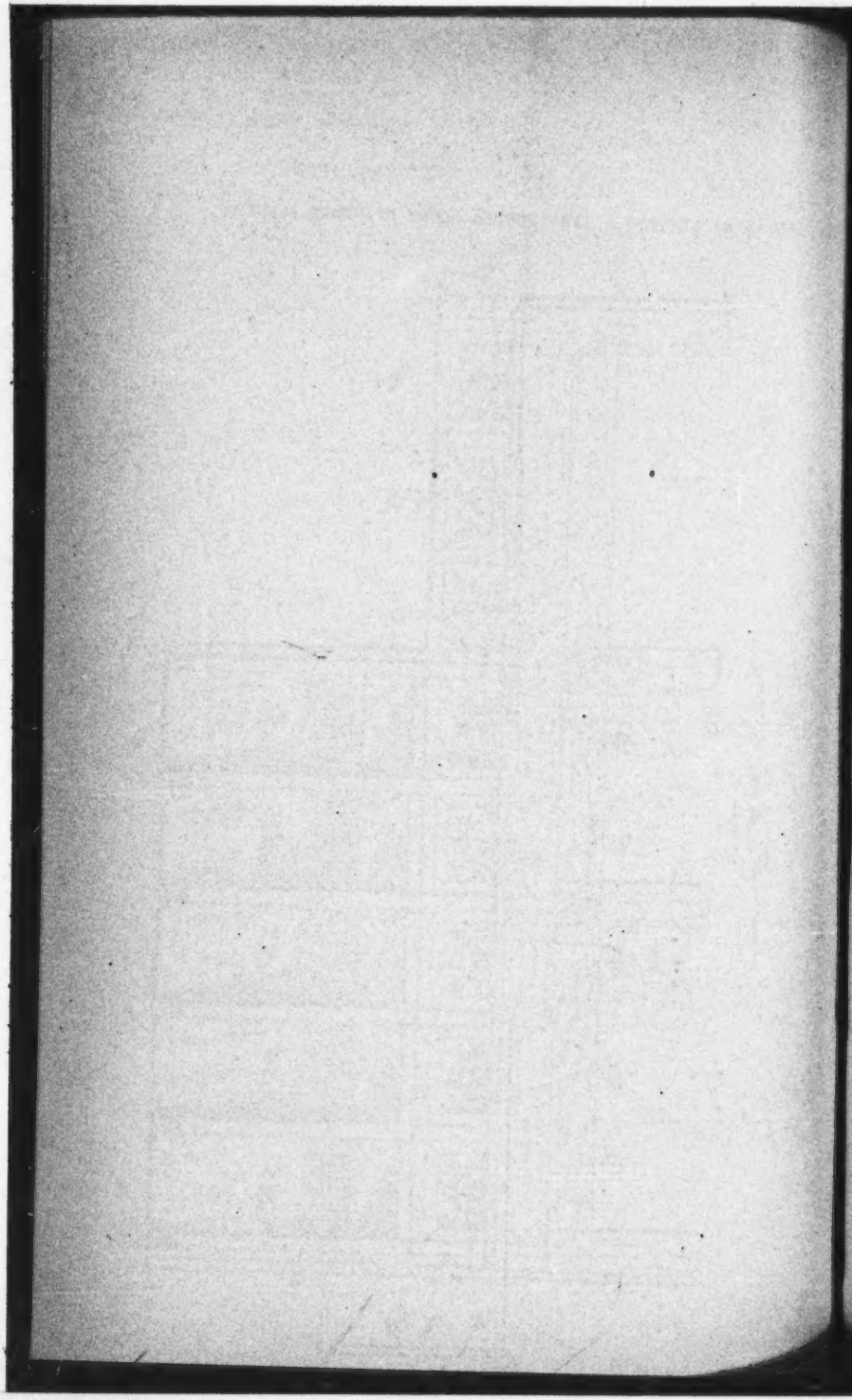
COMPLAINANTS' EXHIBIT, KING JOHN'S COURT STANDARD PLANT.



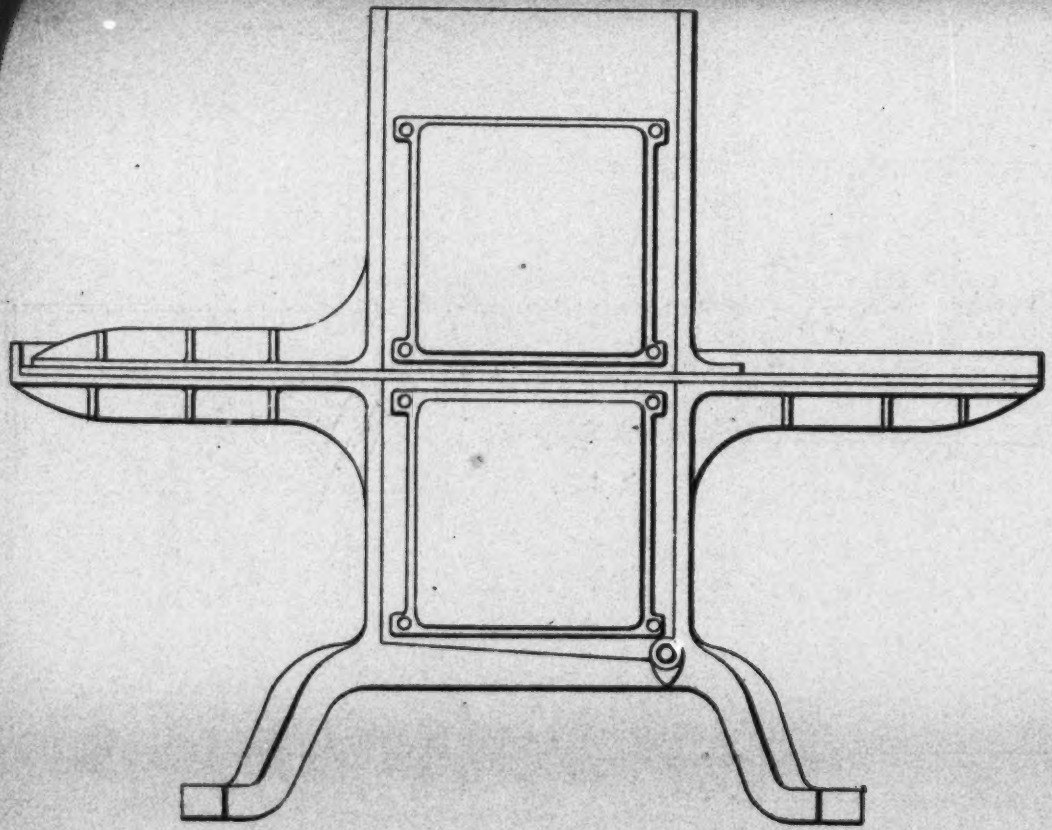


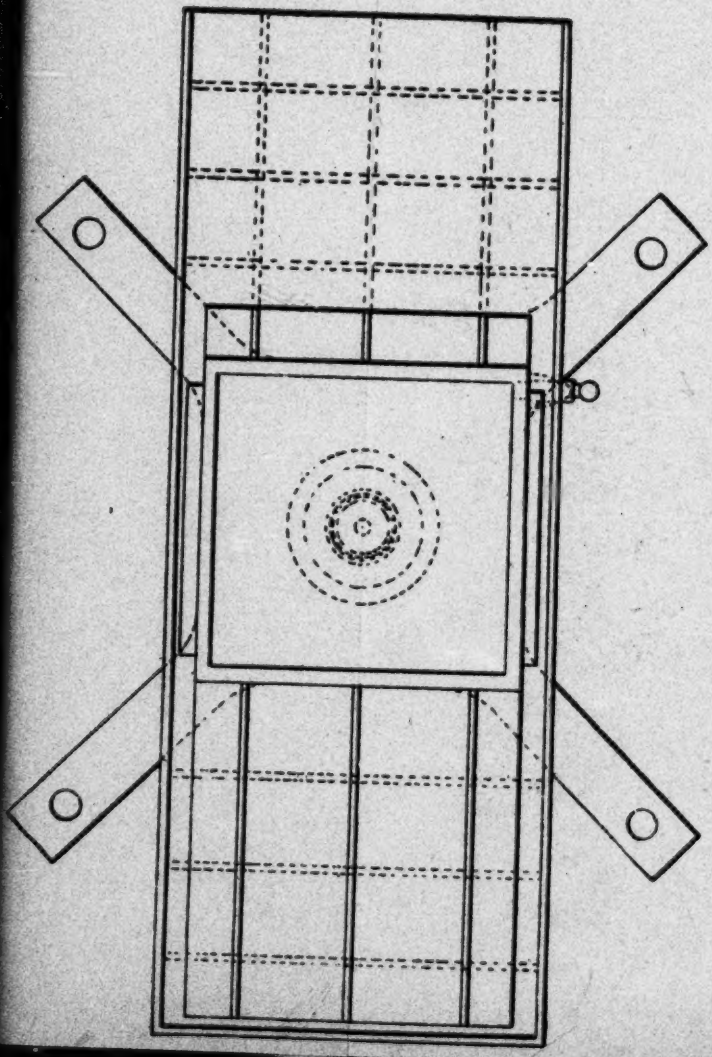
COMPLAINANTS' EXHIBIT, KING JOHN'S COURT STANDARD PLANT.



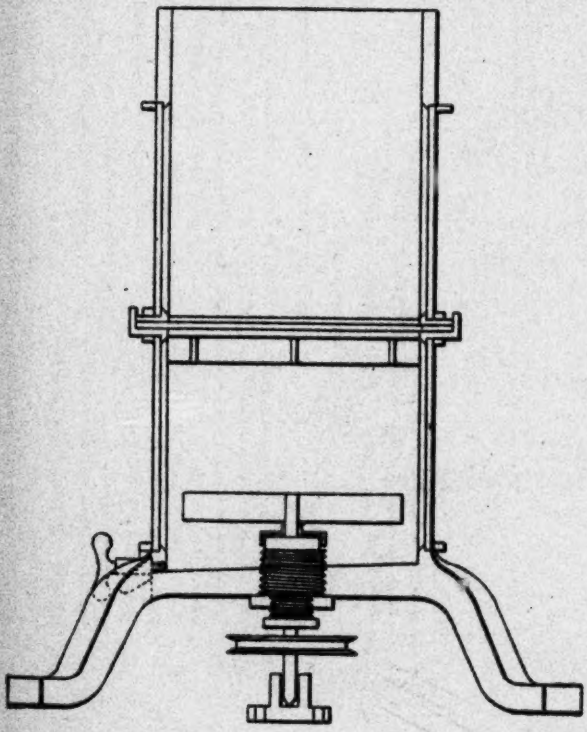


COMPLAINANTS EXHIBIT FIRST TRACING SLIDE MACHINE





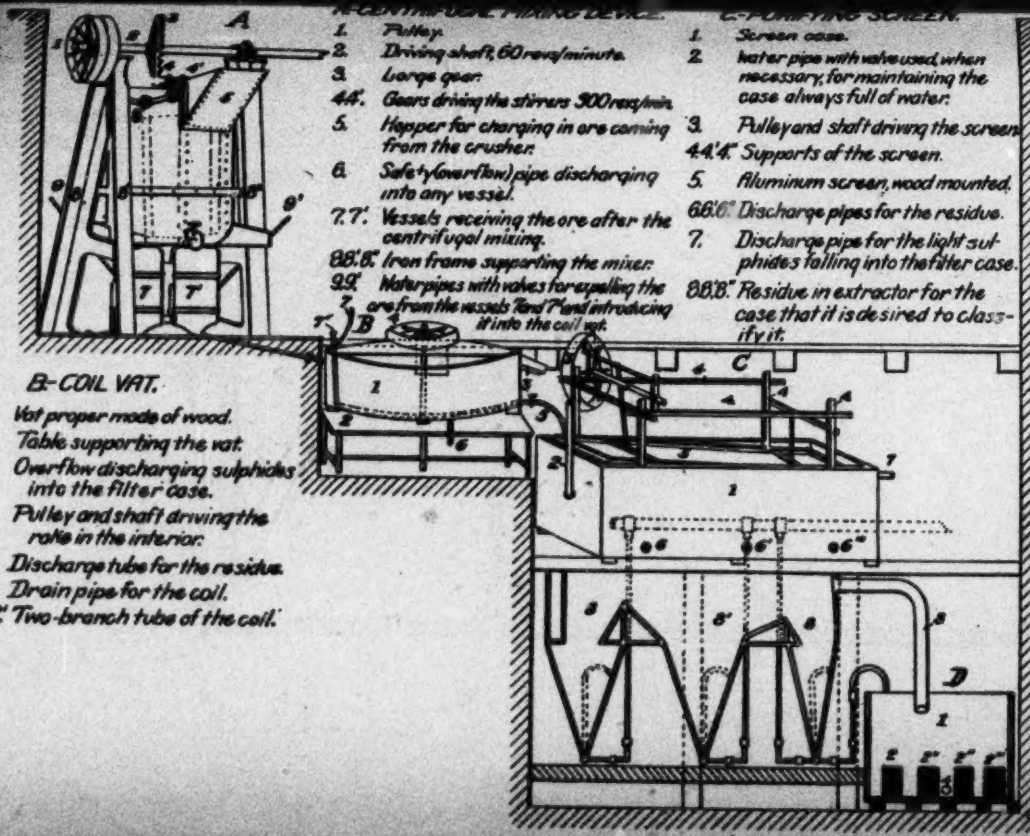
COMPLAINANTS EXHIBIT FIRST TRACING SLIDE MACHINE.



MINERALS SEPARATION LIMITED.
62 London Wall.
Drawing No. 100.
Date.....

Microfilmed by Cornell University Library

COMPLAINANTS' EXHIBIT FROMENT PLAN.



A-CENTRIFUGAL MIXING DEVICE.

1. Pulley.
2. Driving shaft, 60 revs/minute.
3. Large gear.
4.4'. Gears driving the stirrers 300 revs/min.
5. Hopper for charging in ore coming from the crusher.
6. Safety (overflow) pipe discharging into any vessel.
7.7'. Vessels receiving the ore after the centrifugal mixing.
8.8'.8". Iron frame supporting the mixer.
9.9'. Water pipes with valves for expelling the ore from the vessels 7 and 7' and introducing it into the coil vat.

C-PURIFYING SCREEN.

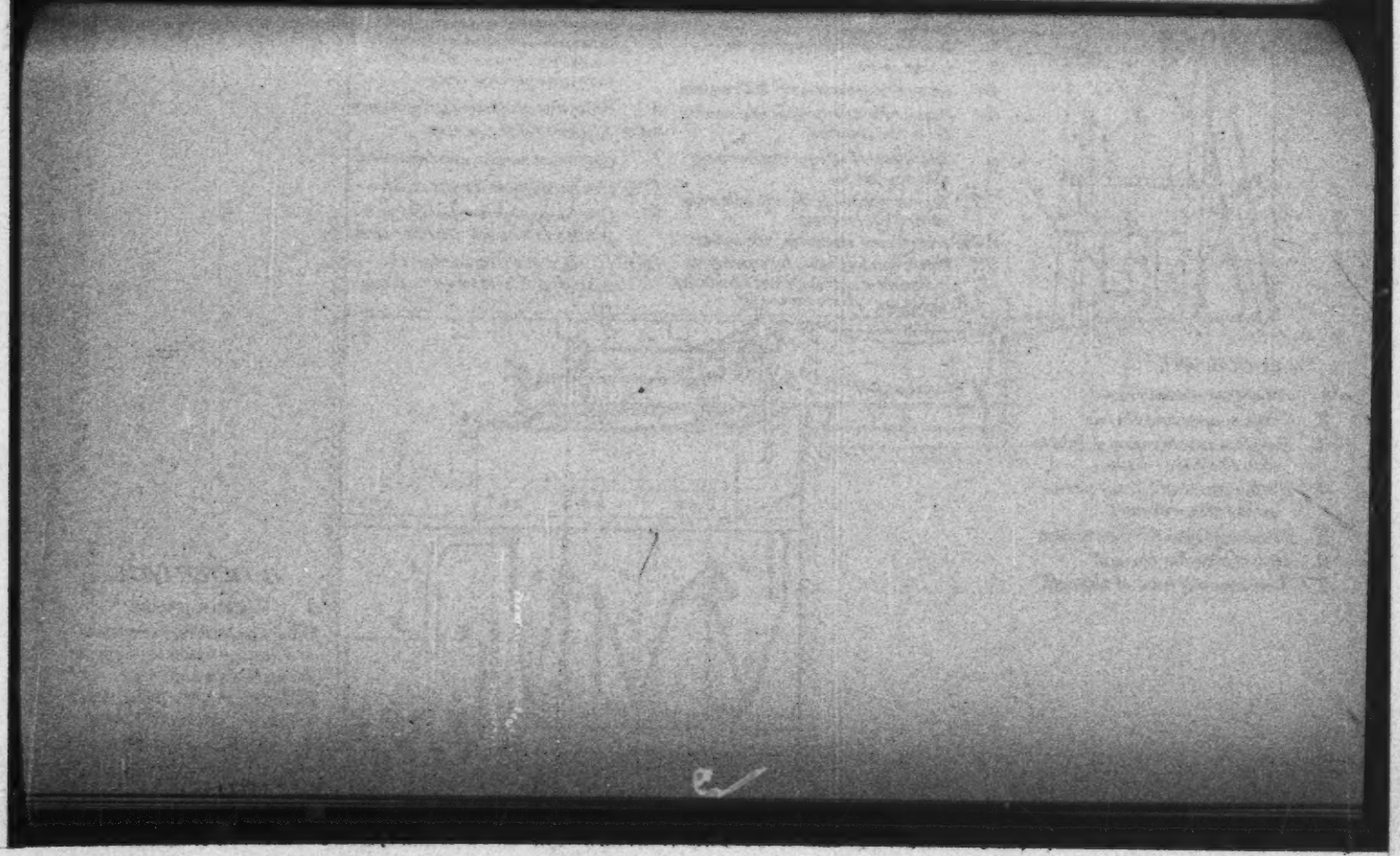
1. Screen case.
2. Water pipe with valve used, when necessary, for maintaining the case always full of water.
3. Pulley and shaft driving the screen.
4.4'.4". Supports of the screen.
5. Aluminum screen, wood mounted.
6.6'.6". Discharge pipes for the residue.
7. Discharge pipe for the light sulphides falling into the filter case.
8.8'.8". Residue in extractor for the case that it is desired to classify it.

B-COIL VAT.

1. Vat proper made of wood.
2. Table supporting the vat.
3. Overflow discharging sulphides into the filter case.
4. Pulley and shaft driving the rake in the interior.
5. Discharge tube for the residue.
6. Drain pipe for the coil.
7.7'. Two-branch tube of the coil.

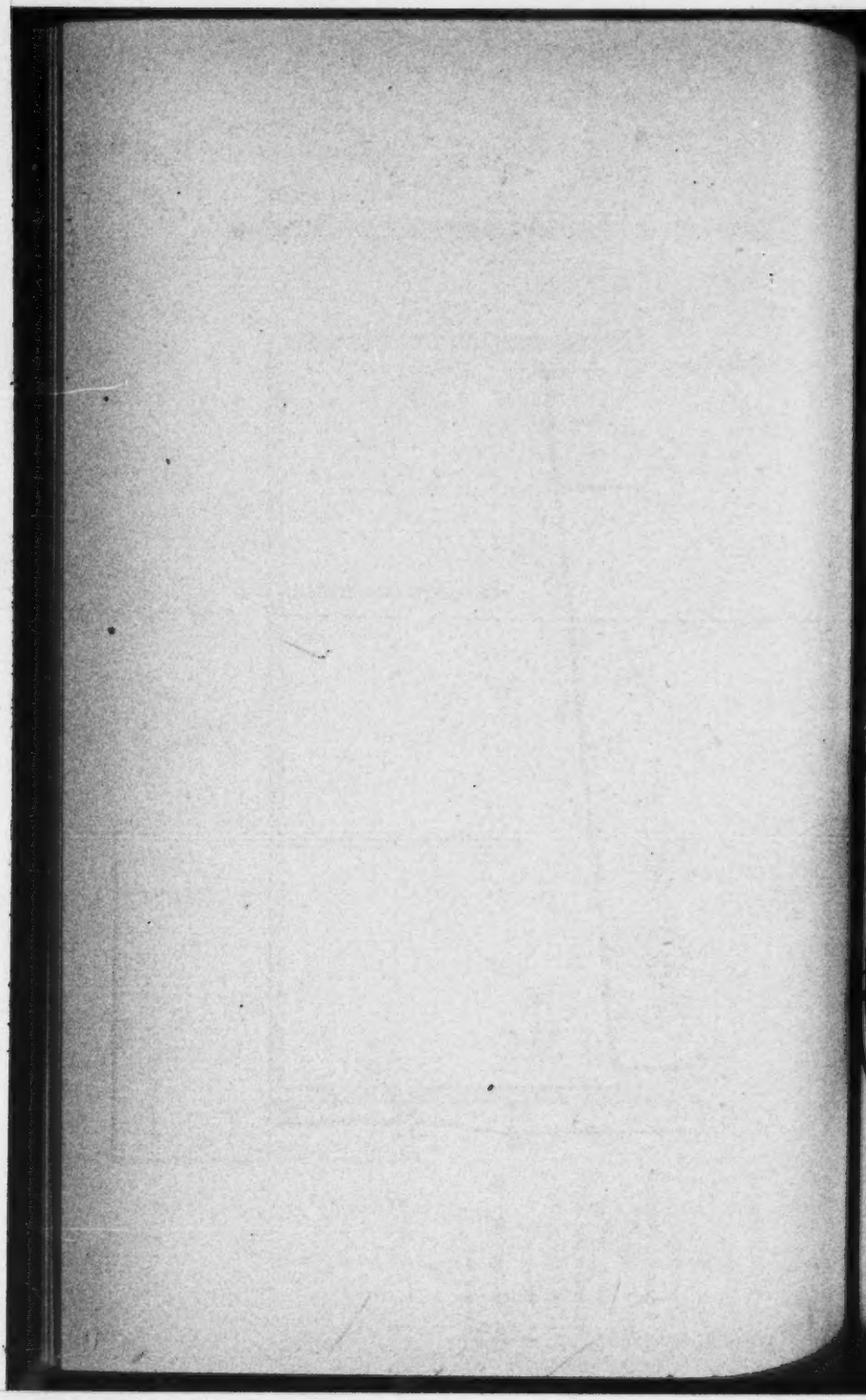
D-FILTER CASE.

1. The case proper.
2.2'.2". Canvas filters consisting of a wooden frame with canvas stretched on both sides. Between the two canvases is contained charcoal powder.
4. Emergency discharge pipe.



COMPLAINANTS EXHIBIT FROMENT DRAWING.-A.

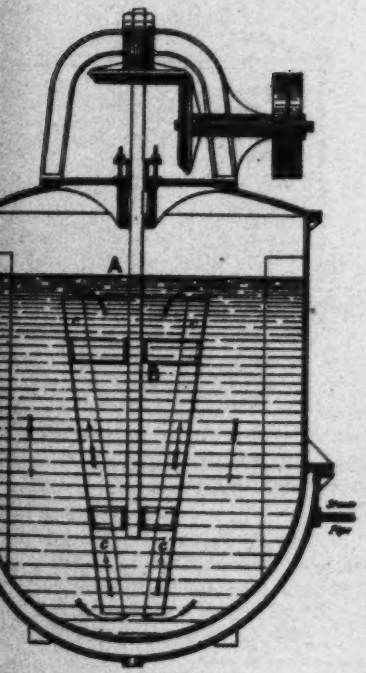
1. Iron Vibrator
2. Spindle.
3. Spring.
4. Eccentric.
5. Iron bracket to be fixed to the vat.
6. Counterweight mounted on the vat.
7. Partitions.
8. Overflow.
9. Rubber iron stop.
10. Screen.



COMPLAINANT'S EXHIBIT-YOUNG FIRST CIRCULAR

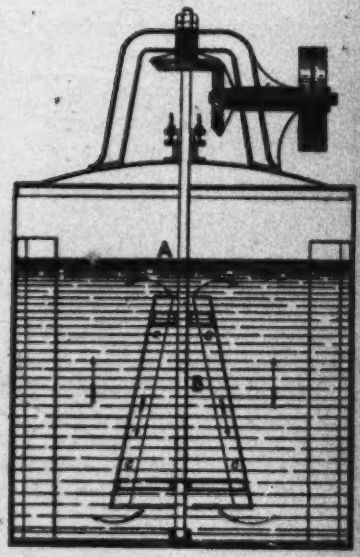
THE RAPID MIXER.

Fig. 1



Cast Iron Tank with Steam Jacket.

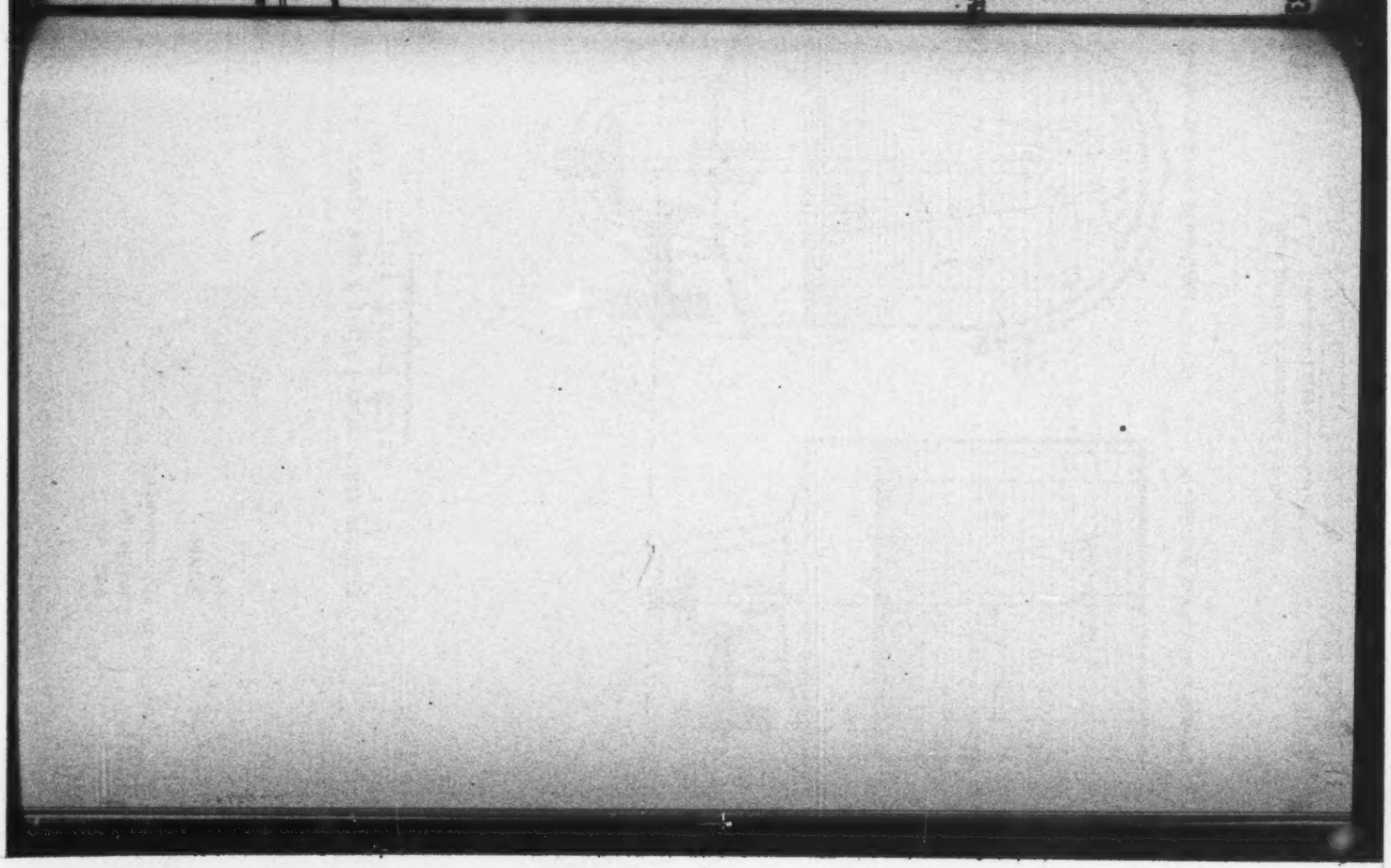
Fig. 2.



Wrought Iron Tank Circular or Square.

Burt, Boulton & Haywood & E. R. Gabbett's

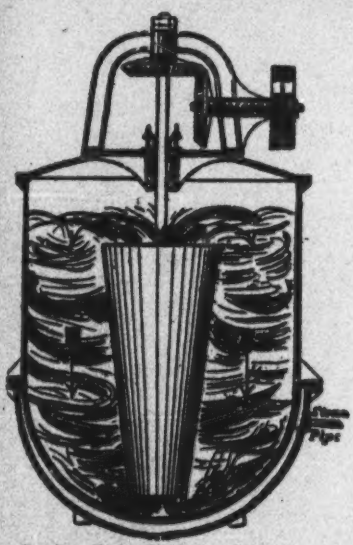
Patent.



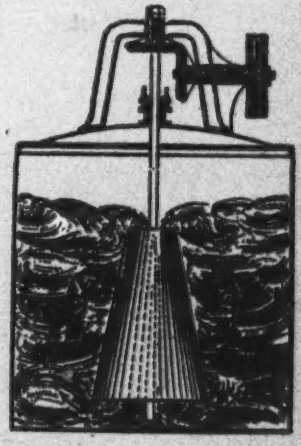
COMPLAINANT'S EXHIBIT—YOUNG ADVERTISEMENT "A"

THE RAPID MIXER.

BURT, BOULTON, & HAYWOOD and E. R. BABBETT'S PATENT.



Cast-Iron Tank with Steam Jacket



Wrought-Iron Tank, Circular or Square.

This Mixer is specially suited for all operations where the perfect Admixture of Liquids or Semi-Liquids is required, irrespective of their difference in Specific Gravity.

ADVANTAGES:—

In Action absolutely Perfect.
Simplicity in Construction, and easily adapted to any Tank.
No Working Parts need come in contact with Materials treated.
Wear and Tear practically Nil
Minimum Power in Driving.

Can be made in any Material, even Glass or Stoneware, and is therefore applicable to the most Corrosive Substances.

All Information and Estimates can be obtained from

MESSRS. H. YOUNG & CO., ECCLESTON IRONWORKS, PIMLICO, LONDON, S.W.
Engineers, Ironfounders, and Manufacturers of Machinery and Constructional Ironwork.

THE RAPID MIXER

BURT, BOULTON & HAYWOOD & E. P. GARRETT'S PATENT.

Telephone No. 3067.

SPECIALLY ADAPTED FOR BREWERIES, TAR DISTILLERS, CHEMICAL AND SEWAGE WORKS.

ROLLED JOISTS, ANGLES PLATES, and TEES, kept in stock.

RIVETED GIRDERS and CASTINGS of every description made in London.

STEEL AND WROUGHT-IRON CONSTRUCTIONAL WORK.

H. YOUNG & CO., LD.

ECCLESTON IRON WORKS, PIMLICO, and BATTLE FOUNDRY WHARF, RIVER ELBE, S.W.

Complainants' Exhibit Young advertisement B.
United States District Court - District of Montana
Minerals Separation Limited and another
vs.
James M. Hyde
London September 5. 1912 J. Phillips Crawley
Examiner

1059 COMPLAINANTS' EXHIBIT YOUNG FIRST CIRCULAR.

The Rapid Mixer is suitable for mixing any description of liquids or semi-liquids, irrespective of their difference in specific gravity.

The acting principle is centrifugal force which operates on that portion of the contents of the vessel A which is enclosed by the revolving cone B, and is thus caused to rotate with the cone by the vanes or vertical baffle plates *c c*.

The material to be treated is thus caused to mount the inside of the cone as shewn in Figure 1, it then flows out over the top, and returns again at the bottom, and the whole contents are thus circulated and turned over with a violent mixing action.

The rapidity of this circulation is governed by the speed at which the cone is driven, but a very moderate rate is sufficient for all practical purposes.

In Figure 2 the cone is inverted and the reverse action to that described above takes place, the contents being drawn from the top and discharged at the bottom, the most suitable form depending on the composition of the materials to be treated.

The advantages claimed for the Rapid Mixer are:—

1. The thorough and complete manner in which the mixing operation is carried out on materials differing very considerably in specific gravity; for example, if mercury and water are placed in the vessel as shewn in Figure 1, the former will be drawn up and distributed in a fine shower through the latter, although the difference in gravity in this case is as 1 to 13.59.

1060 2. Simplicity of form.

3. No working parts need be in contact with the materials to be used.

4. The cone can be made of any material, even stoneware or glass, being thus applicable to the most corrosive liquids.

5. It can be adapted to any existing tank either round or square, and the cones can be used singly or in series.

6. The very small amount of power required in working.

NOTE.—The Rapid Mixer can be made of any size, and the form varied to suit special requirements; it is applicable to all forms of manufacture, where the intimate admixture of liquids or semi-liquids is required.

All information and estimates can be obtained from Messrs. H. Young & Co., Engineers, Eccleston Street, Pimlico, London, and the apparatus can be seen at work by appointment.

(Here follow diagrams marked pp. 1061 and 1062.)

1063 DEFENDANT'S EXHIBITS.

Filed Nov. 6, 1913. Geo. W. Sproule, Clerk.

DEFENDANT'S EXHIBIT CERTIFIED COPY OF FILE-WRAPPER AND CONTENTS OF CATTERMOLE, SULMAN & KIRKPATRICK-PICARD PATENT No. 788,247.

Patent Office letter dated October 4, 1904, rejecting claim 1 on patents to Robson, 575,669, Everson, 348,157, and Elmore, 689,070.
Amendment filed December 31, 1904.

Remarks.

Everson's U. S. Patent, 348,157.

The powdered ore is mixed with an oily substance so as to produce a stiff mass after the materials have been incorporated and thereafter the gangue is washed out of the pasty mass by water. There is no suggestion here of the use of soap or the alternate formation of fatty acid and re-formation of soap.

Everson was ignorant of the chemical facts involved and states that in the case of petroleum or paraffine there is a compound produced between the mineral, water, acid and oil in the concentrates and infers a combination between dilute acid and paraffine. This is untrue; the action of concentration is purely a physical one.

A very important line of distinction between Everson's process and the Applicants' is that Everson oils the whole of the ore and gangue initially as thoroughly as possible and seeks to wash the gangue out of the mass by acid water or the like. The Applicants on the other hand avoid any oiling of the gangue by wetting
1064 the whole first (964—1) with water and by such preferential wetting and the mode of producing the oleic acid only the metalliferous matter present is coated. The Applicants never make a pasty mass of the whole ore but only seek to coat every particle of metalliferous matter as thinly and evenly as possible and therefore to keep the gangue and the mineral particles from agglomerating together.

It is absolutely essential to the success of the Applicants' process that the fatty substance (oleic acid say) must be in the extremest subdivision and must make an intimate contact with the mineral, and the same uniform quantity with regard to any mineral particle, however small this ratio may be. This uniformity cannot be obtained by simply pouring oleic acid into the pulp. The only way of obtaining the small uniform layers of oleic acid on the individual particles is to add a soap solution which permeates the pulp completely, and then decomposing this in situ, i. e. in actual contact with the individual particles.

Respectfully submitted,

KN...T BROS., *Attorneys.*

Washington, D. C., December 31, 1904.

DEFENDANT'S EXHIBIT CERTIFIED COPY OF FILE-WRAPPER AND CONTENTS OF SULMAN, KIRKPATRICK-PICARD PATENT, No. 793,808.

Specification filed October 5, 1903.
Drawing filed December 15, 1903.
Petition and Oath dated September 25, 1903. (965—2)
1065 Patent Office letter dated October 20, 1903.
Applicants are required to supply a drawing illustrating means for carrying out the process described in this application.
The claims are rejected in view of British patent to Lake, 12,778, of 1902, .. ashers.

DEFENDANT'S EXHIBIT CERTIFIED COPY OF FILE-WRAPPER AND CONTENTS OF PATENT IN SUIT No. 835,120.

Petition.

To the Commissioner of Patents:

Your Petitioners Henry Livingstone Sulman, Hugh Fitzalis and Kirkpatrick-Picard and John Ballot, subjects of the King of England, and residents of London, England, whose Postoffice addresses are respectively 44, London Wall, London, E. C., 44, London Wall, London, E. C., and 62, London Wall, London, E. C., pray that Letters Patent may be granted to them, as joint inventors, for the improvements in "Ore Concentration" set forth in the annexed Specification, and they hereby appoint Messrs. Knight Bros., McGill Bldg., Washington, D. C., a firm consisting of Harvey S. Knight and Harry A. Knight, their Attorneys, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the Patent, and to transact all business in the Patent Office connected therewith.
Signed at London, England, this 17th day of May, 1905.
Inventors: HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK-PICARD.
JOHN BALLOT. (966—3)

1066 To all whom it may concern:

Be it known that we, Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard and John Ballot, all subjects of the King of England, and residing in London, England, have invented certain new and useful improvements in Ore Concentration of which the following is a specification:
This invention relates to improvements in the concentration of ores, the object being to separate metalliferous matter, graphite and the like from gangue, by means of oils, fatty acids or other substances which have a preferential affinity for metalliferous matter over gangue.

In the process described in the previous United States Patent No. 777,273, granted to A. E. Cattermole, an amount of oil varying from 4% to 6% of the weight of metalliferous matter present is agitated with an ore pulp so as to form granules which can be separated from the gangue. In the previous United States Patent No. 777,274, granted to A. E. Cattermole and others, a similar method of separation is employed, oleic acid being produced in situ in the ore pulp.

We have found that if the proportion of oily substance be considerably reduced, say to a fraction of 1% on the ore, granulation ceases to take place and after vigorous agitation, there is a tendency for a part of the oil-coated metalliferous matter to rise to the surface of the pulp in the form of a froth or scum.

This tendency is dependent on a number of factors. Thus, the water in which the oiling is effected is preferably slightly
1067 acidified by adding say a fraction of 1% up to 1%, of sulphuric acid or other mineral acid or (967—4) acid salt, the effect of this acidity being to prevent gangue from being coated with oily substance, or in other words, to render the selective action of the oil more marked; but it is to be understood that the object of using acid in the pulp according to this invention is not to bring about the generation of gas for the purpose of flotation thereby, and the proportion of acid used is insufficient to cause chemical action on the metalliferous minerals present.

Again, we have discovered that the tendency for the oily substance to disseminate through the pulp and the rapidity with which the metalliferous matter becomes coated is increased if the pulp is warmed.

The formation of froth is assisted by the fine pulverization of the ore and we find that slime mineral most readily generates scum and rises to the surface while larger particles have less tendency to be included in the froth.

The proportion of mineral which floats in the form of froth varies considerably with different ores and with different oily substances, and before utilizing the facts above mentioned in the concentration of any particular ore a simple preliminary test is necessary to determine which oily substance yields the proportion of froth or scum desired.

The following is an example of the application of this invention to the concentration of a particular ore.

An ore containing ferruginous blende, galena, and gangue
1068 consisting of quartz, rhodonite, and garnet, is finely powdered and mixed with water containing a fraction of 1% or up to 1% of a mineral acid or acid salt, conveniently sulphuric acid, or mine or other waters containing (968—5) ferric sulphate. To this is added a very small proportion of oleic acid (say, from 0.02% to 0.5% on the weight of ore), the mixture is warmed say to 30° to 40° C. and is briskly agitated in a cone-mixer or the like, as in the processes previously cited, for about 2½ to 10 minutes, until the oleic acid has been brought into efficient contact with all the mineral particles in the pulp.

When agitation is stopped a large proportion of the mineral present rises to the surface in the form of a froth or scum which has derived its power of flotation mainly from the inclusion of air bubbles introduced into the mass by the agitation, such bubbles or air films adhering only to the mineral particles which are coated with oleic acid. The minimum amount of oleic acid which can be used to effect the flotation of the mineral in the form of froth may be under 0.1% of the ore, but this proportion has been found suitable and economical.

If the ore were crushed to 90 mesh to the linear inch (half of which ore will pass through 150-mesh sieve) the froth may contain about 70% to 80% of the metalliferous matter present in the ore. This froth is removed from the pulp by spitzkast, upcast, skimming, draining, or otherwise; after subsidence the oil-coated metalliferous matter removed as froth is separated from any liquid which may have accompanied it and treated with a dilute solution of caustic alkali which removes the oleic acid in the form of a solution
1069 of soap.

If desired, the oleic acid used in the first instance may be produced in situ in the pulp by decomposing a dilute soap solution with mineral acid as described in the previous Patent No. 777,274, cited above. The oleic (969—6) acid or other fatty acid forming the coating on the metalliferous matter which produces the froth, may give rise to insoluble soaps on the surface of the metalliferous matter if soluble lime, iron or other salts are present in small quantity during the production, or on the breaking down of the froth with alkali; such insoluble soaps are difficult to remove and are capable of adhering to air and causing flotation much the same as the fatty acids do.

The metalliferous matter which did not form part of the froth (generally the larger particles) remains in admixture with the gangue in the pulp. To recover this, the pulp is distributed in a thin layer on a shaking table, convex buddle or the like, whereon the mineral is exposed to a free air surface, which exposure may be increased by the application of air blast or air jets or the like, and thereafter brought on to the ends or surface of liquid whereby the metalliferous matter floats and is separated from the gangue which sinks as described in the Specification of our previ-
Nov. 20/05. ous United States Application No. 246,637, filed February 20, 1905.

The proportion of mineral recovered in the froth and that recovered by table flotation may be considerably varied but gen-
1070 erally speaking the froth will separate the slime mineral while the larger particles are recovered by the latter method.

Sub. A, Apr. 17/06. The accompanying drawing is a diagram of one form of apparatus suitable for carrying this invention into practice.

[Matter enclosed between rules erased in copy.]

" " " Referring to Fig. 1 a mixing

A [mixing]* vessel A (of which there may be any number in series) is provided with a rotatable stirrer B. Crushed ore is fed from a hopper C into the vessel by a (970—7) band D. A pipe E controlled by a tap E^1 delivers circuit water to the vessel, and oleic acid or other oil is introduced through the pipe F and tap F^1. The other cock G from the vessel A communicates through a swan-neck pipe H with the froth separating apparatus.

In passing from the frothing apparatus A to the spitzkasten (say between O and K) the pulp may if desired

be run in a thin layer over a smooth slightly inclined plane

5½

Canceled Apr. 24/06.
Nov. 20/05, Canceled.
Apr. 17/06, Canceled.

and may be submitted to the action of a series of air jets in order to increase the amount of floating metalliferous matter to a maximum. [as illustrated in our previous application above referred to.]*

[Matter enclosed between rules erased in copy.]

The froth separating apparatus comprises several (say three) pointed boxes J^1, J^2, J^3 which open at the top into a horizontal channel consisting of side walls K. The channel has a narrow inlet K^1 and spreads out to a wide outlet K^2. The pointed boxes J^1, J^2, J^3 have full-way cocks L^1, L^2, L^3, at the bottom leading to swan-neck discharge pipes M^1, M^2, M^3. An up-current of water may be led in at the bottom of each through a tap N^1, N^2, N^3.

1071

The boxes are all filled with circuit water; the pulp from the vessel A is distributed horizontally from the flat trough O through the inlet K^1. The heavy sands and coarser particles of mineral sink into the first box J^1 from which they are led to a shaking table, convex buddle or the like to be treated as above described. The middlings or medium sands fall into the box J^2 and if they contain any mineral may be removed for further treatment by agitation. The up-current of water from the taps N^1, N^2 prevents the deposition of any slime in these boxes. The fine sands or gangue slimes settle in the last box J^3 from (971—8) which they are discharged to waste or further treatment.

The slime mineral in the form of froth or scum floats from the liquid and is carried by the stream over the outlet K^2 into a launder P and thence to a filter Q where the metalliferous matter is removed from the circuit water which is returned to the vessel A by a pump R. The circuit water may be brought to the proper temperature by passing it through a heater S having a burner S^1 before admitting the water to the vessel A.

An alternative method for the recovery of any sunk oiled metalli-

[* Words and figures enclosed in brackets erased in copy.]

erous matter which may be deposited in the second and third spitzkasten is as follows: The products suspended in circuit liquor are removed from the spitzkasten and placed in a vessel in which they are submitted to an additional pressure of air or other gas of from,
1072 say, 1 to 2 atmospheres, or over. On relief of such pressure the bubbles of air, or other gas so generated throughout the mass at once sweep to the surface thereof all the metalliferous matter in the form of a froth which can be separated as before.

Insert A[1]. Apr. 17/06. The nature and arrangement of the apparatus used may be varied without departing from this invention.

Insert A[2]. Apr. 17/06. What we claim as our invention and desire to secure by Letters Patent is:—

1. The herein described process of concentrating ores which consists in mixing the powdered ore with water, adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter, (amounting to a fraction of 1% on the ore), agitating the mixture until the oil-coated mineral matter forms into a froth, and separating the froth from the remainder by flotation. (972—9)

2. The herein described process of concentrating ores which consists in mixing the powdered ore with slightly acidified water, adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter (amounting to a fraction of 1% on the ore), agitating the mixture until the oil-coated mineral matter forms into a froth and separating the froth from the remainder by flotation.

3. The herein described process of concentrating ores which consists in mixing the powdered ore with slightly acidified water, adding a small proportion of an oily liquid having a preferential
1073 affinity for metalliferous matter (amounting to a fraction of 1% on the ore), warming the mixture, agitating the mixture until the oil-coated mineral matter forms into a froth and separating the froth from the remainder by flotation.

4. The herein-described process of concentrating ores which consists in finely powdering the ore, mixing it with slightly acidified water, adding a small proportion of an oily substance having a preferential affinity for metalliferous matter (amounting to a fraction of 1% on the ore), warming the mixture, agitating the mixture until the oil-coated mineral matter forms into a froth separating the froth from the remainder by flotation, and removing the oily coating from the mineral.

5. The herein-described process of concentrating ores which consists in mixing the powdered ore with water, adding a small proportion of oleic acid amounting to 0.02–0.05% on the ore, agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, and separating the froth from the remainder of the flotation. (973—10)

6. The herein described process of concentrating ores which consists in mixing the powdered ore with water containing a fraction of [less than]* 1% of sulphuric acid, adding a small proportion of oleic acid amounting to 0.02–0.5% on the ore, agitating the mixture until the Oleic acid

has been brought into efficient contact with the mineral and has formed a froth therewith, and separating the froth from the
1074 remainder by flotation.

7. The herein described process of concentrating ores which consists in mixing the powdered ore with
Apr. 17/06. water containing a fraction of [less than]* 1% of of sulphuric acid, adding a small proportion of oleic acid amounting to 0.02–0.5% on the ore, warming the mixture to 30°–40° C., agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, and separating the froth from the remainder by flotation.

8. The herein described process of concentrating ores which consists in finely powdering the ore, mixing it with
Apr. 17/06. water containing a fraction of [less than]* 1% of sulphuric acid, adding sufficient oleic soap solution to produce oleic acid amounting to 0.02–0.5% on the ore, warming the mixture to 30°–40° C., agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth therewith, separating the froth from the remainder by flotation, filtering off the froth and removing the oleic acid therefrom by

Insert A³,
Apr. 17/06.> treatment with an alkali.

Canceled Apr. 17/06.

9. The herein described process of concentrating ores which consists in finely powdering the ore, mixing it with water containing

(974—11) 11.

1075 less than 1% of sulphuric acid, adding sufficient oleic soap solution to produce oleic acid, amounting to 0.02–0.05% on the ore, warming the mixture to 30°–40° C., agitating the mixture until the oleic acid has been brought into efficient contact with the mineral and has formed a froth with the finer mineral, distributing the mixture on the surface of a current of water running over columns of water, so that the coarser minerals and sands, the finer sands and the gangue slimes successively deposit out while the froth is floated away by the current, filtering off the froth and removing the oleic acid therefrom by treatment with an alkali and separating coarser mineral from the sands by exposing them
Nov. 20/05. alternately to air and water on a shaking table.

[Matter enclosed between rules erased in copy.]
[* Words and figures enclosed in brackets erased in copy.]

In testimony whereof we have signed our names to this Specification in the presence of two subscribing witnesses.

HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK-PICKARD.
JOHN BALLOT.

Two Witnesses:
GEO. J. B. FRANKLIN.
T. J. OSMAN.

Oath.

See Oath filed Apr. 17/06.

LONDON, ENGLAND, ss:

Henry Livingstone Sulman, Hugh Fitzalis, Kirkpatrick-Picard and John Ballet, the above-named petitioners, being duly sworn, depose and say that they are subjects of the King of England
1076 and residents of London in England; and that they verily believe themselves to be (975—12) the original, first and joint inventors of the improvements in "Ore Concentration," described and claimed in the annexed Specification; that they do not know and do not believe that the same was ever known or used before their invention or discovery thereof; or patented or described in any printed publication in any country before their invention or discovery thereof, or more than two years prior to this application; or patented in any country foreign to the United States on an application filed more than twelve months before this application; or in public use or on sale in the United States for more than two years prior to this application; and that no application for patent on said improvements has been filed by them or their representatives or assigns in any country foreign to the United States, except as follows: Great Britain No. 7803, dated 12th April 1905, and Australia.

HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK-PICARD.
JOHN BALLOT.

Sworn to and subscribed before me this 17 day of May, 1905 by all three Deponents.

[NOTARIAL SEAL.] G. F. WARREN,
Notary Public.

(Revenue Stamp.)

1077 Consulate-General of the United States of America for Great Britain & Ireland at London.

I, Richard Westacott, Vice and Deputy Consul-General of the United States of America at London, England do hereby make known and certify to all whom it may concern that George Frederick Warren, who hath signed the annexed Certificate, is a Notary Public, duly admitted and (976—13) sworn and practising in the

city of London aforesaid, and that to all acts by him so done full faith and credit are and ought to be given in Judicature and thereout.

In Testimony Whereof, I have hereunto set my hand and affixed my Seal of Office at London aforesaid, this Nineteenth day of May in the year of our Lord One Thousand Nine Hundred and five.

[CONSULAR SEAL.]

——— ———,
Vice and Deputy Consul-General.

Patent Office Letter, Dated August 9, 1905.

Data *is* required as to the Australian application referred to in the oath; such data should be supported by affidavit. The filing data of the application referred to in line 6, page 5 should be inserted. The jetting means (last two lines, page 5) are required to be illustrated, as is also the apparatus for the alternative procedure described in the second paragraph of page 7, as well as the shaking table form recited in claim 9. The particular apparatus should not be made an essential of a process claim such as the 9th.

LEWIS B. WYNNE,
Examiner, Division XXV.

T. F. MITCHELL.

1078 *Amendment Filed November* 20, 1905.

The above named application is hereby amended as follows:

The Australian application was not filed at the time of filing of this application.

Page 5, to the end of line 6, add "filed February 20, 1905."

Page 6, to the end of line 1, add—as (977—14) illustrated in our previous application above referred to.

It is thought that the requirement as to the showing of the jetting means should be waived in view of this amendment.

An additional drawing will be filed showing the alternative procedure described on page 7.

Claim 9, lines 17 and 18, cancel "on a shaking table."

Respectfully submitted,

KNIGHT BROS., *Attorneys.*

Washington, D. C., November 18, 1905.

Patent Office letter dated November 23, 1905.

Case as amended November 20, 1905, further considered.

The amendment inserted at the end of line 1, page 6, is nothing more than a reference to another application for details which should appear in this case. Such reference is not permissible. Illustration of the jetting means will therefore be insisted upon. It is required
1079 that the expression "water containing less than 1 per cent of sulphuric acid" be replaced by one more definite in such claims as contain the expression. It may mean water without

a trace of sulphuric acid. It is suggested that "water containing a fraction of 1 per cent of sulphuric acid" be substituted.

The drawing should be filed at once. A complete response to an action dealing with formal matters must include response to every item.

LEWIS B. WYNNE,
Examiner, Division XXV.

T. F. MITCHELL. (978—15)

Amendment Filed April 17, 1906.

The above-named application is hereby amended as follows:

A new oath is filed herewith.

The Examiner will kindly place "Fig. 1" on the original sheet.

Add the sheet of drawing filed herewith.

Referring to the original specification, on page 5, cancel lines 13, 14 and 15 and insert the following:

A. 1080 "In the accompanying drawings,

"Figure 1 is a diagram in perspective illustrating one form of apparatus suitable for carrying this invention into practice, and,

"Figure 2 represents is perspective an apparatus for carrying out a secondary step in the process."

Page 5, line 16, change "A mixing" to *Referring to Fig. 1 a mixing.*

Page 7, line 19, after "before" insert

A^1. *This idea* is not claimed broadly in this case but forms the subject matter of an application filed by us on January 9, 1906, Ser. No. 295,326.

On page 7 of the original specification, three lines from the bottom, add:

A^2. Referring to Fig. 2, a mixing vessel *a* (of which there may be several) in series) is provided with a rotatable stirrer *b*. Crushed ore or similar finely divided mineral is fed into the vessel *a*. A pipe *c* controlled by a tap *c'* delivers circuit water to the vessel and in cases where oil is used, the oil is introduced through the pipe *d* in quantity sufficient to produce a

(979—16)

thin coating of oil on these mineral particles for which oil has an affinity.

The pulp mixed with oil escapes over the lip of the discharge conduit *a'* and passes through the pipe a^2 to a pump *e*.

Hence the pulp is pumped through discharge pipe *e'* 1081 into the closed chamber *f* which is constructed to withstand a considerable internal pressure and is pro-

vided with a safety valve f^1, the pressure gauge f^2, and a gauge glass f^3 to indicate the level of the pulp in the chamber. An outlet pipe g having a cock g' leads to a series of spitzkasten h filled with circuit water.

The operation is as follows:

Th- cock g' is closed; pulp is pumped into the chamber which contains air or other gas and the pumping is continued until the pressure in the chamber rises to, say, 50 to 100 lbs per square inch. The pressure is sufficient to cause the air or other gas to be dissolved to a considerable extent in the pulp. After the lapse of a few minutes for the due solution of the compressed air or a portion of it by the pulp or the liquid, the cock g' is opened and the pulp is discharged into the open spitzkasten h where the liquid is of course under atmospheric pressure. The pump e may be stopped during [furing]* this discharge.

Apr. 24/06.

The whole of the mineral to which air bubbles are attached, say the oiled, mineral, at once rises to the surface as a coherent scum or froth. A surface current of water is maintained in the spitzkasten and the floating material is thus removed and separated from the gangue which remains sunk or suspended in the liquid."

not entd. +Page 5, cancel from and including "may" line
corrected 3, to and including "maximum" page 6, line 1
Apr. 24/06. (980—17)

1082 Also concel the insert at the end of line 1, page 6.

Claims 6, 7 and 8, line 3, change "less than" to *a fraction of*
Cancel claim 9.
Insert the following claims:

A³ 9. The process of concentrating powdered ores which consists in separating the mineral from the gangue by coating the mineral with oil in water containing a small quantity of oil, agitating the mixture to form a froth, and separating the froth.

10. The process of concentrating powdered ores which consists in separating the mineral from the gangue by coating the mineral with oil in water containing a small quantity of oil, warming the mixture, agitating the mixture to form a froth, and separating the froth.

11. The process of concentrating powdered ores, which consists in separating the mineral from the gangue by coating the mineral with oil in water containing a small quantity of oil and a quantity of acid insufficient to cause chemical action on the metalliferous minerals present, agitating the mixture to form a froth, and separating the froth.

[* Words and figures enclosed in brackets erased in copy.]

Canceled June 29/06.

D[333]. 12. The process of concentrating powdered ore which consists in separating the minerals from gangue by coating the minerals with oil in water containing a fraction of 1% of oil on the ore, and recovering the oil coated minerals.

[Matter enclosed between rules erased in copy.]

12 [12].* The process of concentrating powdered ore which consists in separating the minerals from gangue by coating
1083 the minerals with oil in water containing a

18.

Canceled June 15/06. fraction of 1% of oil on the ore, agitating the mixture to cause the oil coated mineral to form a froth, and separating the froth from the remainder of the mixture.

14. The herein described process of concentrating ores which consists in mixing powdered ores with water, adding a small proportion of oily liquid having a preferential affinity for metalliferous matter, (amounting to a fraction of 1% on the ore) agitating the mixture until part of the oil-coated mineral matter forms into a froth, removing the froth, subjecting the remaining pulp to the action of a compressed gas in a closed chamber, and thereafter relieving the pressure whereby gaseous bubbles are liberated in the pulp and raise the oil-coated mineral particles to the surface.

[Matter enclosed between rules erased in copy.]

Insert B, Apr. 24/06.>

Respectfully submitted,

KNIGHT BROS., *Attorneys.*

Wash., D. C., April 14, 1906.

KINGDOM OF GREAT BRITAIN AND IRELAND,
City of London, England, ss:

Henry Livingstone Sulman, Hugh Fitzalis-Kirkpatrick-Picard, & John Ballot, being sworn, depose and say that they are subjects of the King of England, and residents of London, England, that they verily believe themselves to be the original, first and joint inventors of the improvement in Ore Concentration described and claimed in

[* Words and figures enclosed in brackets erased in copy.]

the application filed May 29, 1905, Ser. No. 262,889 that they do not know and do not believe that the same was ever known or used before their invention or discovery thereof, or patented or described in any printed publication in any country before their invention or discovery, or more than two years prior to this application, or patented in any country foreign to the United States on an application filed more than twelve months before this application, or in public use or on sale in the United States for more than two years prior to this application; and that no application for patent on said improvement has been filed by them or their representatives or assigns in any country foreign to the United States, except as follows:—

1084

Great Britain, April 12th, 1905, under No. 7803.

HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK-PICARD.
JOHN BALLOT.

Sworn to and subscribed before me this 3d day of January, 1906.

[CONSULAR SEAL.] RICHARD WESTACOTT,
Vice and Deputy-Consul-General of the United States of America at London, England.

Patent Office Letter Dated April 20, 1906.

Case amended April 17, 1906, further considered.

"Furing," last line, page 2 of the amendatory paper should be corrected. The data as to the cancellation directed on page 5 are incorrect; said amendment cannot be made until corrected data are furnished.

In presenting claim 14, applicants make a change of election in shifting from the shaking-table step of original claim 9 to the air compression and flotation step. This change is made after the case has been twice acted on by the office, and is too late. Said claim 14 (983—20) is required to be cancelled. Applicants may, if they so desire, restore original claim 9.

1085

LEWIS B. WYNNE,
Examiner, Div. XXV.

T. F. MITCHELL.

Amendment Filed April 24, 1906.

The above-named application is hereby amended as follows:

In the amendment filed April 17th, page 2, last line, change "furing" to *during*

Page 5, cancel matter beginning "and may" line 29 and ending page 6, line 1, with "maximum."

Insert the following claims—

B. 13 [14 15].* The herein-described process of concentrating ores which consists in finely powdering the ore, mixing

[* Words and figures enclosed in brackets erased in copy.]

it with water containing less than 1% of sulphuric acid, adding sufficient oleic soap solution to produce oleic acid amounting to 0.02-0.5% on the ore, warming the mixture to 30°-40° C., agitating the mixture until the oleic acid has been brought into efficient contact with the mineral, and has formed a froth with the finer mineral, distributing the mixture on the surface of a current of water running over columns of water, so that the coarser minerals and sands, the finer sands and the gangue slimes successively deposit out while the froth is floated away by the current, filtering off the froth and removing the oleic acid therefrom by
1086 treatment with an alkali and separating the coarser mineral from the sands by exposing them alternately to air and water. (984—21)

We think the Examiner will upon reconsideration not hold that claims 14 and 15 are alternative.

Beginning page 6, line 15, applicant states that the material of the first spitzkasten is treated on the shaking table, while in lines 12 et seq., page 7, he states that the material of the second and third spitzkasten is treated by the process set forth in claim 14. It will thus be seen that the two steps may be employed together and, therefore, are not alternative.

Respectfully submitted,

KNIGHT BROS., *Attorneys.*

Washington, D. C., April 23, 1906.

Patent Office Letter Dated April 26, 1906.

Case as amended April 24, 1906, further considered.

Applicants are again and finally required to cancel claim 14. Applicants specifically state that the method thereof is alternative with that covered by claim 15, and the fact that one may be substituted for the other for the treatment of part does not make them any the less alternative and independent processes. The next step must be either compliance with this requirement or appeal to the Board of Examiners-in-Chief.

LEWIS B. WYNNE,
Examiner, Div. XXV.

T. F. MITCHELL.

Amendment filed June 15, 1906. (985—22)

1087 The above-named application is hereby amended as follows:—

Cancel claim 14 and adjust the numerals of the remaining claims.

Respectfully submitted,

KNIGHT BROS.,
Attorneys.

WASH., D. C., June 15, 1906.

Patent Office letter dated June 18, 1906.

Case as amended June 15, 1906, further considered.

Claim 12 is rejected in view of 763,260, Cattermole, June 2[illegible] 1904; or 793,808, Sulman et al., July 4, 1905, Washers (H), as e[illegible] pressing merely a difference of degree thereover as to the proporti[illegible] of oily matter employed.

LEWIS B. WYNNE,
Examiner, Div. XXV.

T. F. MITCHELL.

Amendment Filed June 29, 1906.

The above-named application is hereby amended as follows:

Cancel claim 12 and adjust the numerals of the remaining claim[illegible]

Respectfully submitted,

KNIGHT BROS.,
Attorneys.

Washington, D. C., June 29, 1906. (986—23)

Notice of Allowance dated July 6, 1906.

Endorsement, class 83, Mills, Ore and Coal Washers. (987—2[illegible]

1088 DEFENDANT'S EXHIBIT EXTRACT FROM "TREATISE ON CHE[illegible] ISTRY APPLIED TO THE MANUFACTURE OF SOAP AN[illegible] CANDLES."

Flotant Soaps.

Under this title are designated those soaps which, when in a sta[illegible] of paste, are batted or inflated with air, by which means its buoyanc[illegible] becomes such, that the soap floats in the water. It is a favorite soa[illegible] not only on account of whiteness and mildness, but the facility wi[illegible] which it gives a lather. These soaps are colored and perfumed e[illegible] actly as are the toilet soaps generally. It must be remarked, how[illegible] ever, that the olive, palm, and sweet almond oil soaps are the onl[illegible] ones that can be converted into flotant soaps, it being impossible t[illegible] inflate those soaps made of suet or lard. They are prepared fro[illegible] either of the preceding soaps, by cutting it into thin shavings an[illegible] melting over a water-bath, with twelve pounds of water to every fif[illegible] pounds of soap. When the mass is in perfect fusion, it is agitate[illegible] with a twirling fan (Figs. 54, 55), until it froths and foams to th[illegible] top of the vessel.

(Here follows diagram marked p. 1088.)

Fig. 54.

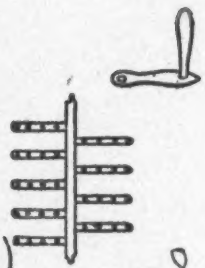
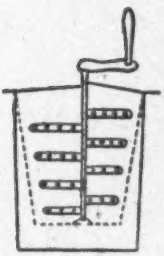


Fig. 55.



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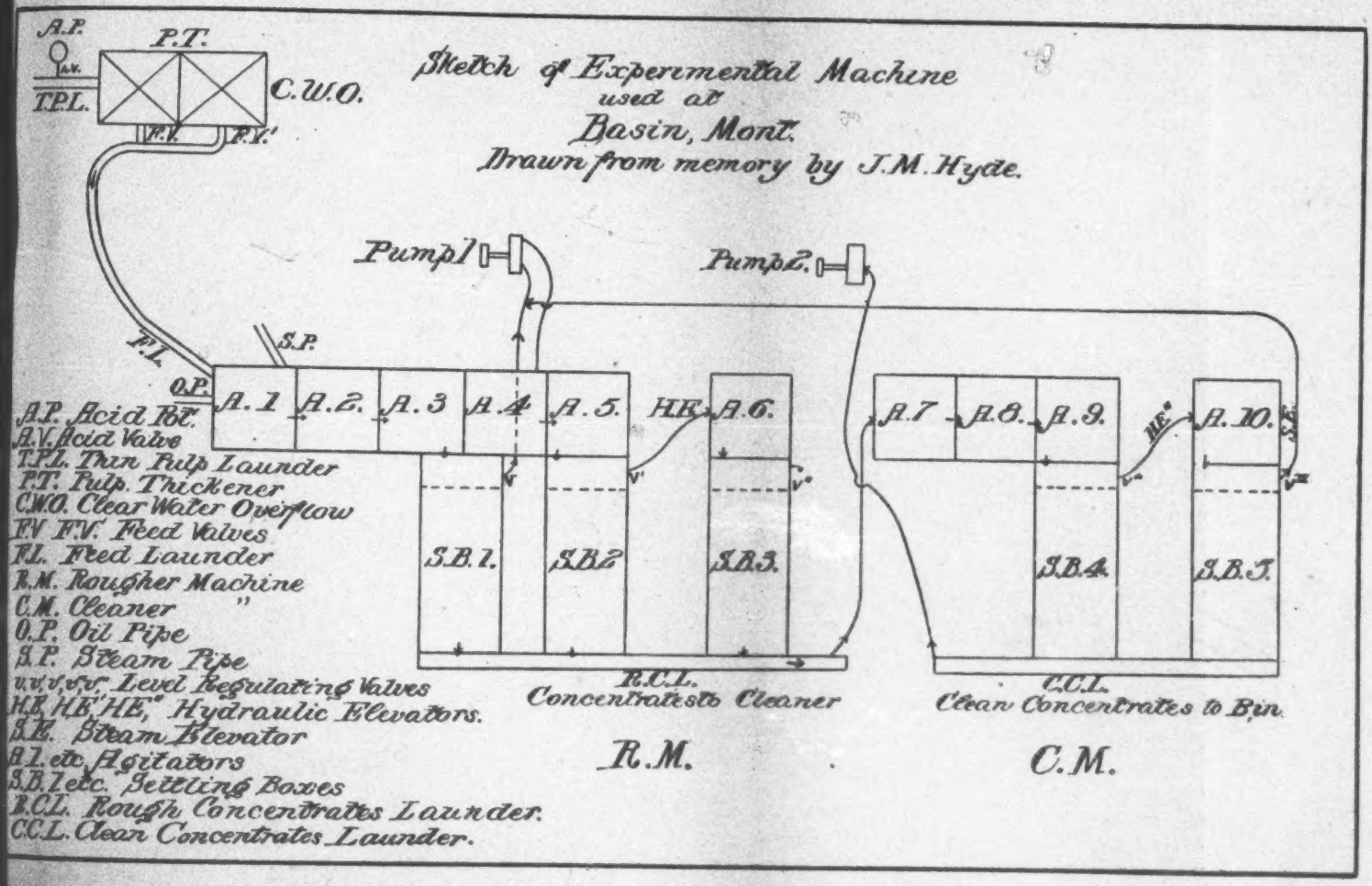
ion, Ltd. et al.
v.
HYDE.

Page 1088

Defendant's Exhibit Hyde Sketch of Experimental Machine.



403

1089 Fig. 54 represents the twirling fan detached from the water bath; it is made to revolve on a pivot, and to be taken on or off at will. After the perfume has been added, the contents are emptied out into cooling frames or moulds. (988)

(Here follows diagram marked p. 1090.)

1091 [DEFENDANT'S EXHIBIT DRAWINGS AND SPECIFICATION OF LETTERS PATENT No. 345,951, PATENTED JULY 20, 1886, ISSUED TO HEZEKIAH BRADFORD.]

(Here follows diagrams marked pp. 1092 and 1093.)

1094 United States Patent Office.

HEZEKIAH BRADFORD, of Philadelphia, Pennsylvania.

Method of Saving Floating Materials in Ore-Separation.

Specification Forming Part of Letters Patent No. 345,951, Dated July 20, 1886.

Application Filed June 22, 1885. Serial No. 169,342. (No Model.)

To all whom it may concern:

Be it known that I, Hezekiah Bradford, of Philadelphia, in the State of Pennsylvania, have invented an Improvement in Methods of Saving Floating Materials in Ore-Separation, of which the following is a specification.

Almost all metallic ores—coal and other substances—when pulverized, contains a greater or less proportion of particles of ore or metal that will, even if pulverized in water, float on the surface of the water, and the finer the substances are pulverized the greater the proportion of floating particles. These floating particles appear to possess some peculiar quality which repels the water from their surfaces, especially when such particles are exposed, even momentarily, to atmospheric air, and when such exposure takes place the water is repelled from a sufficient portion of their surfaces to cause such particles to float off on the surface of the waste water from the other particles that sink in the water.

In concentrating ores they should be pulverized fine enough to liberate the metallic particles and the particles of native metals from their gangue. They are then, or should be, sized with screens. The larger sizes are, or should be, concentrated in jigs. The finer sizes are, or should be, concentrated by concussion-tables similar to the "Rittinger table," or by some of the various vanning-machines.

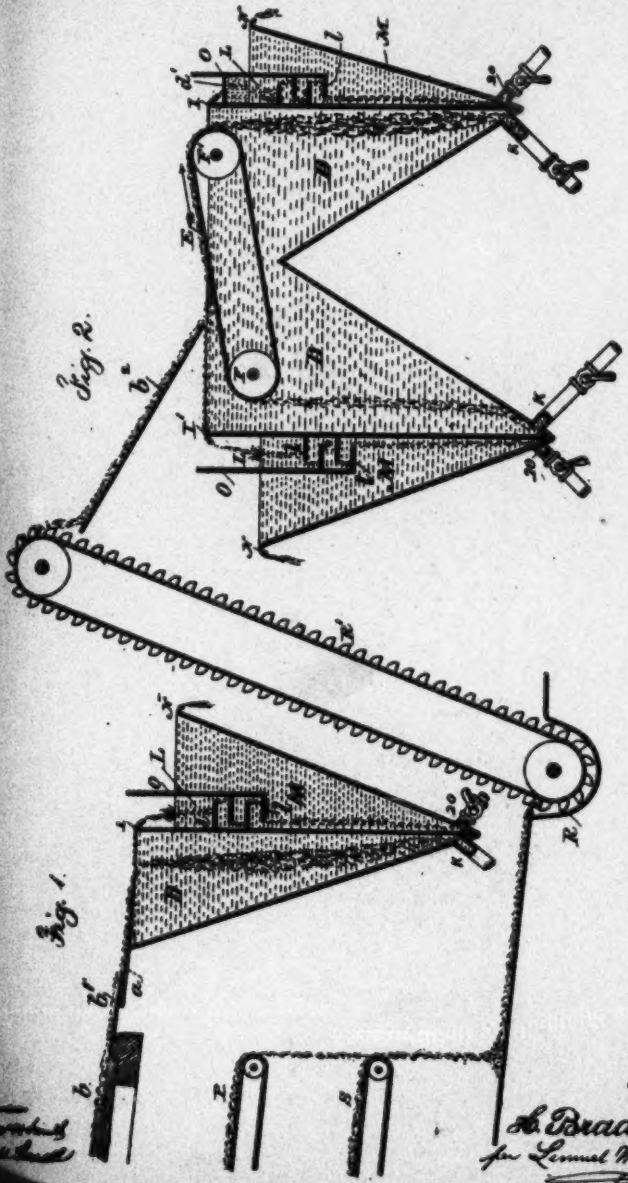
In amalgamating ores the quicksilver will not act on the base metallic ores; neither will it act on the particles of native metal unless the particles are brought in contact with the quicksilver, and consequently all the particles that float off over the amalgamating-pan are lost.

(No Model.)

H. BRADFORD.

METHOD OF SAVING FLOATING MATERIALS IN ORE SEPARATION.

No. 345,951. Patented July 20, 1886.



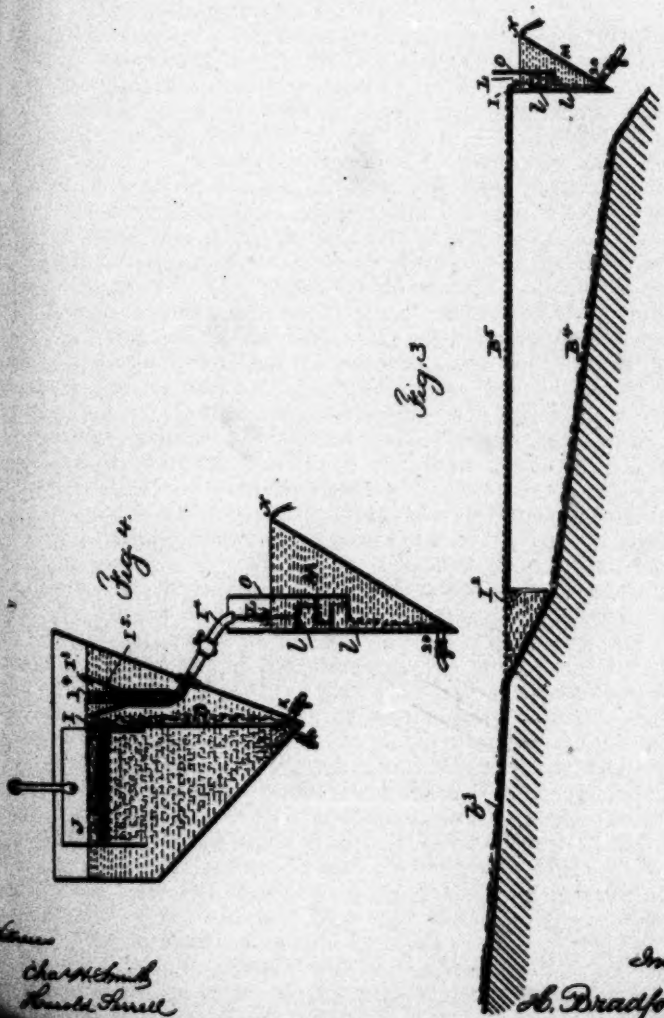
Inventor
H. Bradford.
per Lemuel W. Serrell
Atty

(Model.)

H. BRADFORD.

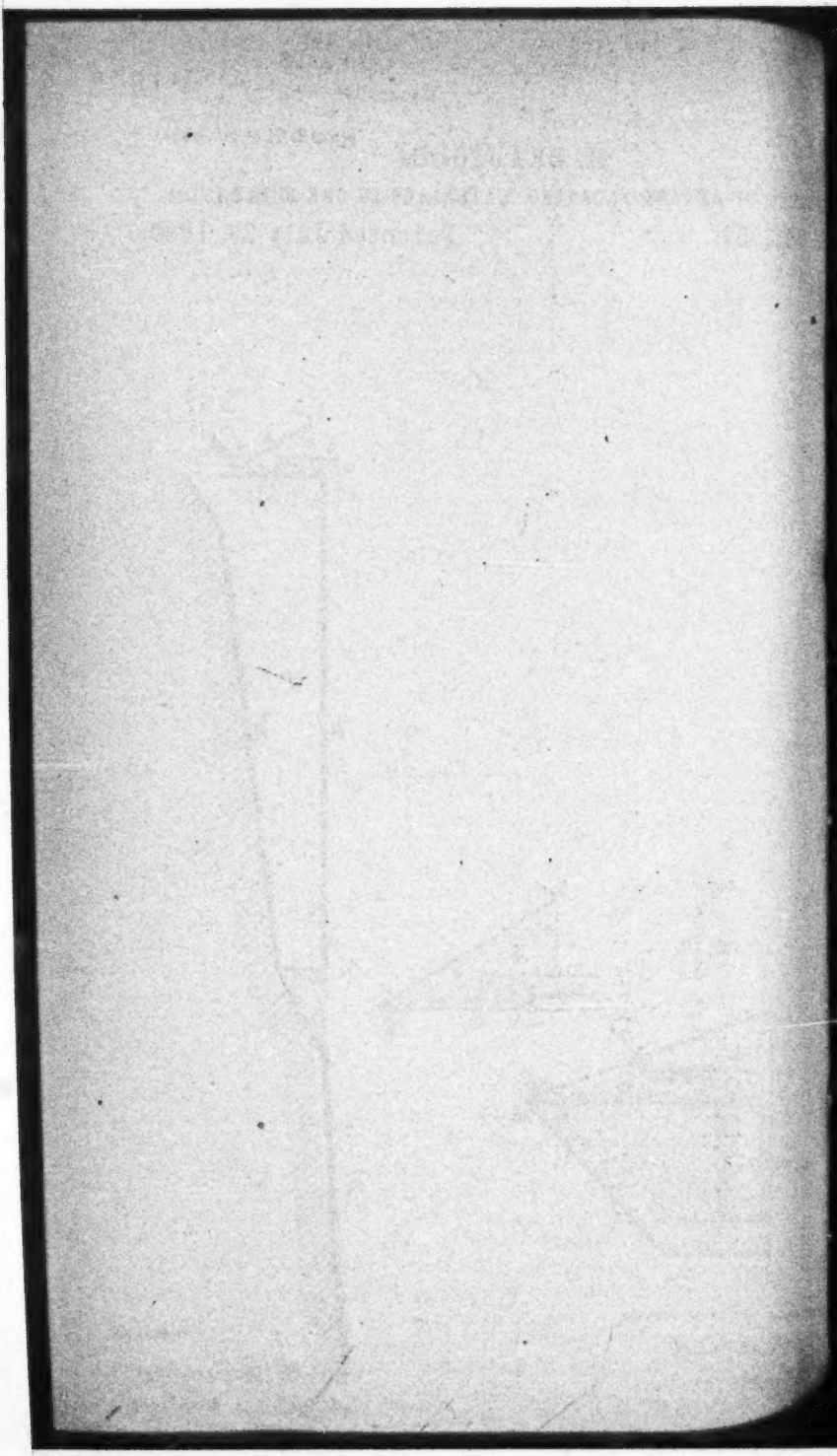
METHOD OF SAVING FLOATING MATERIALS IN ORE SEPARATION.

No. 345,951. Patented July 20, 1886.



Witness
Chas. H. Smith
Harold Serrell

Inventor
H. Bradford
for Lemuel W. Serrell



In the concentration of coal from slate as heretofore practiced a considerable proportion of coal, iron pyrites, and some slate will float off and be lost, and there are many other substances which while being concentrated or washed in water have heretofore floated off and been lost.

In the drawings, Figure 1 is a section representing my improvement as applied to the separator known as the "Rittinger table." Fig. 2 represents the improvement as applied to an ore-separator of the class known as the "Frue vanner." Fig. 3 represents the improvement as adapted to a trough or similar delivery device through which the tailings pass, and Fig. 4 represents the improvement as adapted to the tailings from a jig.

My present invention consists in a method of saving floating materials in ore-separation by passing such floating materials along upon the surface of the water, with but little agitation of the water, thus preventing such materials from subsiding, and then causing the waters and floating materials to plunge or fall into a water-receptacle, and retaining said floating materials in said receptacle until they lose their floating power and sink. To accomplish this I attach to the end of the table *b* a metal plate, *b'*, on a level with the table and of the same descent, and fit it so evenly as to cause no ripple in the water as it passes from the table to the plate. This plate is wide enough to catch all the tailings, the waste water, and the floating material as these substances leave the lower end of the table, and catch none of the concentrations, and as the line where the concentrations and tailings meet on the table changes back and forth this plate must be so attached to the end of the table that it can be moved back and forth as this line changes on the table. This plate *b'* must be attached also as nearly parallel as possible with the line of motion of the table.

Under the plate *b'*, and as close to it as possible, I provide a stationary metal plate, *a*, which receives the water, the tailings, and the floating material without ripple, and conveys the same to the top of the water in tank D. This plate *a* is preferably a little more inclined than the plate *b'*, as it has no motion. Both plates should have just descent enough to deliver the substances upon the top of the water in tank D with as little force as possible, and the plate *a* should touch the top of the water, so that the substances will not plunge under the water of the tank D or make any unnecessary ripple; nor should said plate *a* dip under the water, as that would cause an eddy in the current on the top of the water by the discharge of the substances from plates *b'* and *a*, and this eddy, by detaining the floating particles, would cause some of them to sink among
1095 the tailings. As soon as these substances strike the water of the tank D, the tailings will immediately sink to the bottom of the tank, while the floating particles will pass, with a part of the waste water, over the overflow I of tank D into a receptacle, L, in tank M, with a fall sufficient to plunge the floating particles under water. This receptacle L should be small enough so that the whole surface of the water therein will be constantly acted upon by the plunging water, in order to thoroughly wet the floating particles,

some of which will rise many times to the top of the water before they get wet enough to sink; and to insure the fall of the water, so as to cover the whole surface of the receptacle L, a perforated plate, d', may be used, as shown in Fig. 2, with holes enough and large enough to shower the water over the whole of this receptacle L. In this receptacle L, I provide a series of shelves, l, to break the force of the plunging water, so that when it passes down below the lower shelf with the metallic particles it will produce no agitation in the main body of the water in the tank M, and the particles that floated are so thoroughly wet as to sink below the bottom shelf, and to continue to sink until they reach the bottom of tank M, and they will not float again without exposure to atmospheric air. The water will pass off at the overflow N of tank M free from floating material. Where there is not fall enough from the end of table b or the end of vanners P and S, or where plates like b' could not be attached for conveying the tailings, the waste water, and the floating materials directly to the tank D without ripple, the substances must be conducted to trough R, from which these substances must be raised by an elevator, R', high enough to be deposited in the trough or incline b^2, which will deliver them upon the belt E, a portion of which is immersed in water in tank D, and the upward motion of this belt will elevate these tailings and floating materials out of the water, so that atmospheric air will come in contact with the tailings. When the belt delivers these substances again to the water, the tailings will immediately sink in the water to the bottom of the tank D, while the particles that repel the water will float and pass off over the overflow I into a receptacle, L, of tank M, similar to that shown in Fig. 1, where all the floating particles will become wet enough to sink, and the waste water will pass away at the overflow N. All the particles that float on the top of the water, as the substances are deposited in the water on the belt E, will float out at the overflow I' into a tank similar to M, where these particles will sink and the waste water pass off free from floating material. The belt may be made of rubber, like a Frue-vanner belt, with ridges on both edges to prevent the substances from running over the sides of the belt, or it may be made of any other suitable material, but should have ridges at the edges of the belt. The belt should fit the tank closely, so that the floating particles from the lower end of the belt will pass off at the overflow I'. All the tanks should be discharged at the bottom continuously through stop-cocks or other equivalent means. Where the waste-water way has but little descent, I provide a trough, b^3, Fig. 3, at an incline just enough to carry ... these substances a sufficient distance to procure, if possible, a depth for the dam I^2 of at least twelve inches. The floating particles will pass with a small portion of the waste water to the dam I, and the tailings will pass away at the bottom of the dam with part of the waste water, which will carry off all the tailings.

The dam I, vessel M, and the parts for saving the floating material are similar to those shown in Fig. 1.

Where the ore is too coarse in size to be concentrated on tables, it is generally concentrated in jigs, (see J, Fig. 4). Any particles

that float on the water will pass out of the jig J with the tailings at the overflow I. The tailings will sink in the water in the tank D as soon as they pass this overflow, and will be discharged at the bottom of the tank by the pipe and cock K, and the floating material will pass, with a portion of the waste water, into a receptacle, I^3, which is contracted at the bottom to a size just sufficient to form a pocket, I^5, that will hold an upright pipe, I^4, in the center of this receptacle, which pipe ought to be of sufficient size to carry off a part of the waste water and all of the floating material from the jig. The bottom of the pocket is extended through the side of the jig, and has a stop-cock at the end, where the waste water and the floating material should be continuously discharged into a receptacle, L, in the tank M. The conical receptacle I^3 should have a flat side toward the overflow, extending the whole length of the overflow of the jig, and should be placed just far enough, but no farther, from the overflow I to allow all the tailings to settle before the waste water and floating material reach the receptacle I^3. The reason for this is, that some of the floating particles have only a little floating capacity, and many will sink before they float far. When they once float over the receptacle I^3 with part of the waste water, the current caused by the suction of the discharge-pipe I^4 in the center of the receptacle I^3 will draw the floating particles, and the waste water and the floating material are discharged into the receptacle L in the tank M, where the floating material will be saved, as before described. Any particles that sink in the receptacle I^3 before they reach the pipe I^4 can be discharged from the receptacle by raising the pipe I^4 from the pocket.

All the tanks are discharged at the bottom through stop-cocks, which should be so regulated as to discharge just water enough to carry out their respective deposits.

1096 If it should be desirable to again expose the tailings from tank D and trough B^4 to the action of atmospheric air, they can be conducted in any convenient way to a trough, like R, elevated by an elevator, like R′, and delivered onto a belt, like E, in tank D, where such particles as would float could be saved.

The shelves in receptacle L, instead of being horizontal, may be placed at an angle sufficient to discharge the particles of floating material as fast as such particles settle on such slanting shelves—say at an angle of seventy-five degrees—which will prevent agitation in the water in the main body of the tank nearly or quite as well as the horizontal shelves, taking care to have ample room for the water to pass away between the shelves.

In depositing the water, tailings, and floating material on the belt E, a small portion of fine tailings may, in the agitation caused by such deposit, pass off into tank D at the lower end of belt. Any such tailings will sink in the tank and pass off at stop-cock K.

This improvement is available with ores or tailings that are either in a wet or dry condition. When such materials are in a dry condition, they are to be scattered upon the water by sifting or otherwise near the surface, so as to fall upon the water with but little concussion. A part of the metallic portions will float, and

most of the earthy portions will absorb moisture and sink. I therefore do not limit myself to any particular manner of supplying the material to be operated upon, or of causing the particles that are to be separated to float.

I do not claim a separating device in which the water and tailings from a stamp or other reducing-machine pass through a pipe to a vessel in which the particles of ore are to be gathered as they float, because in so doing the materials that may have floated are carried down under water and considerable sinks. By my improvement any particles that come to the surface are kept up, so that they may not sink until they reach the place where they are saved.

I do not herein lay claim to the means employed for the conduct of the method, but reserve the right to apply for a separate patent thereon.

I claim as my invention—

The method herein specified of saving floating materials in ore-separation, consisting in passing the water and floating materials along in an open unobstructed sheet from the table or separating-machine with but little agitation of the water, thus preventing such materials from being carried beneath the surface and subsiding, then causing the water and floating materials to plunge or fall into a water-receptacle, and then retaining said floating materials in said receptacle until they lose their floating power and sink, substantially as specified.

Signed by me this 20th day of June, A. D. 1885.

HEZEKIAH BRADFORD.

Witnesses:

GEO. T. PINCKNEY,

WALLACE L. SERRELL.

1097 [DEFENDANT'S EXHIBIT SPECIFICATION OF LETTERS PATENT No. 348,157, DATED AUGUST 24, 1886, ISSUED TO CARRIE J. EVERSON.]

1098 United States Patent Office.

CARRIE J. EVERSON, of Chicago, Illinois.

Process of Concentrating Ores.

Specification Forming Part of Letters Patent No. 348,157, Dated August 24, 1886.

Application Filed August 29, 1885. Serial No. 175,665. (Specimens.)

To all whom it may concern:

Be it known that I, Carrie J. Everson, of Chicago, in the county of Cook and State of Illinois, have invented a certain new and useful Improvement in Processes of Concentrating Ores; and I do hereby declare that the following is a full, clear, and exact description thereof.

The discovery which forms the basis of my invention is that metals and metallic substances in a comminuted state will unite with compounds of fats or oils and acids, and that such compounds will not unite with comminuted quartz or other rocky gangue. The essential feature of the method which constitutes my invention, therefore, consists in commingling with pulverized ore a fat or an oil, either animal, mineral, or vegetable, or a fatty constituent or acid of an animal or vegetable fat or oil, or any constituent of a mineral oil, together with an acid, either mineral or vegetable, or a soluble neutral or acid salt, for the purpose of effecting a union of the free metal or metallic portion of the ore with such admixed material, whereby the same may be retained in the subsequent separation of the quartz or other rock therefrom by washing or other suitable means.

The invention is more specially applicable to the treatment of ores in which the metal or metallic portion is mixed with quartz or other rock as distinguished from the mixture of mineral with clay, though it is applicable to ores containing alumina, together with quartz or other rock, to the extent of permitting the removal of the silica or sand.

The operation of concentration as a whole, or in its practical form as applied to the separation of rocky mineral ores, involves the reduction of the quartz or other rock containing the mineral to a powder, the addition thereto of the fat or oil and acid or salt, and the subsequent removal of the gangue.

If my invention is inapplicable to any particular rocky ores or class or classes of rocky ores, or to the concentration of any particular metal, such limitations are not now known to me. Its commercial value, however, will probably be restricted to its use in connection with ores bearing the precious metals, such as gold, silver, and copper.

Among the ores upon which I have operated successfully by means

of my invention are the following: Ores containing native gold and silver, kerargyrite, argentite, argentiferous galena, and a variety of double and otherwise compound sulphides of silver, with copper, antimony, arsenic, and other base-metal sulphides. I have also operated successfully upon pyritic ores, white, yellow, green, and intermediate shades, having variable constituents of iron, copper, arsenic, and sulphur, and mostly auriferous, and having variable proportions of such constituents. I have also operated successfully upon ores containing tellurides of gold, silver, and lead, and others containing the oxides and carbonates of copper and the carbonate of lead. All the metals or metallic mineral portions of these ores are acted upon by the admixture described, in such manner as to permit the rocky gangue to be removed by a washing process, after which the several metals may be separated by the usual means.

In putting my invention into practice any fat or oil, and any acid, either mineral or vegetable, or any soluble neutral or acid salt, or any compound of fats and oils with appropriate acids, may probably be successfully employed, at least such is the case with all of these agents with which I have so far experimented. I have used petroleum and one of its several constituents—namely, paraffine-oils—also tallow, (melted,) lard, lard-oil, red-oil, (impure oleic acid,) cotton-seed oil, castor-oil, sperm-oil and linseed-oil, and some combinations of these with each other. The acids which I have employed are sulphuric, hydrochloric, nitric, phosphoric, acetic, oxalic, tannic, and gallic. I have also used the following salts, to wit: the sulphates and chlorides of sodium, zinc, and copper, and the double sulphate of potash and alumina. The selection of the appropriate agents will, however, be largely determined in the practical working of my invention by the consideration of economy, which will obviously exclude the greater number of those above enumerated. A reasonable cheap and practicable use of my invention will be as follows, the quantity named being suitable for laboratory use and the character of the ore specified being substantially that of an ore upon which I have successfully operated by the preparation and in the manner hereinafter described.

1099 Take an ore assaying twelve ounces per ton in silver and containing forty-eight per cent. silica, 6.3 per cent. zinc, 1.5 per cent. copper, fifteen per cent. iron and aluminium, 6.5 per cent. lead, 14.18 per cent sulphur, 7.19 per cent. arsenic. Of this ore take four (4) ounces by weight in pulverulent form, prepare a mixture containing sulphuric acid, cotton-seed oil, and water, in all about twelve fluid drams, of which ten drams are of water and about two drams are acid and oil in the proportions of fifteen parts of oil and two parts of the acid by measure. In making this fluid mixture the acid and oil are first mixed with each other, the acid being added to the oil very gradually, so that the temperature will not rise above 120° Fahrenheit. The stirring in of the acid should be thorough, as it tends at first to gravitate to the bottom. After a few hours, in a summer temperature, the mixture will be ready for use, and, preferably, in such a temperature should not be prepared long before using, though if it should have stood long enough

to solidify it should be gently heated before adding the water thereto. In winter or in air-tight vessels it may be kept for a number of weeks or even longer, and then rendered fit for mixing with water by heating gently when required for use. The water may be advantageously added in installments of about three equal parts, and the mixture stirred after each addition of water until it stiffens. After stirring in the entire quantity of water the compound is added to the ore, the proportions of ore and compound being chosen with a view to producing a stiff mass after the materials have been incorporated, such proportions being therefore variable in different cases with this end in view. The stirring or incorporation of the ore with the liquid should of course be thorough for the purpose of bringing the mineral into contact with the oil and acid as completely as possible, and after such incorporation the mass is then in condition for the washing out of the quartz by the action of water which will be applied to the mass in sufficient quantities for this purpose. The washing should promptly follow the mixing, and in this operation the mass be opened out or broken up and throughly stirred in the water, in order that the sand or quartz may be freed and carried away. In treating so small a bulk as above specified the mass may be squeezed repeatedly in the hand in a basin of water, the substance so manipulated being expressed between the fingers each time it is squeezed, and thus made to expose new surfaces to the water from which the sand will be detached, so as to fall to the bottom of the basin. In practice upon large masses any vessel having an outlet or outlets at its bottom for the escape of the water and sand will be suitable for this operation of washing, and mechanical means will of course be employed to break up the mass. The concentrated mineral will accumulate in a pasty mass or lump or lumps and will contain the metallic portion of the ore, together with the hydrated oil and acid, which latter may be removed by heating and afterward roasting, or by other suitable means. The use of petroleum or of a constituent thereof, either by itself, or in combination with tallow, (heated,) cotton-seed oil, or other fat or oil, will be even less expensive.

When petroleum or a constituent thereof is used the oil should desirably be first mixed with the ore, then water added containing a suitable amount of free acid or a soluble neutral or acid salt, the quantity of water being ample for the washing-out operation, which is to follow, and the quantity of acid sufficient to cut the sand away from the otherwise cohering mass. In the case of petroleum or its constituent, paraffine-oil, one or two fluid drams of acid to one gallon of water is sufficient for this purpose. The petroleum which I have used was 30° Baumé, and I have found three fluid drams of oil abundant for properly moistening two ounces of heavy ore, or in the ratio of about a barrel of oil to the ton of ore, the amount being, of course, variable with the relative bulkiness of the ore.

In the use of petroleum, or of a liquid constituent thereof, like paraffine-oil, the condition of the concentrated mass is more liquid than when a vegetable or an animal oil or a fatty constituent thereof

is used, and a somewhat different means or method should be employed for removing the sand. In practice, the concentrate, after through agitation of the mass and detachment of the sand, will in this case be preferably removed by means of a constant overflow of water from a washing-out vessel, by which overflow the concentrate will be floated off. Devices and methods now well known in wet separation of ores will be suited to this part of the operation, bearing in mind that the sand and mineral are merely transposed or their relative positions are reversed, because the sand is heavier than the mixture of mineral, oil, and acid. A proper selection of devices for this purpose will be apparent to those skilled in the wet separation of ores. After removing the quartz or rock by washing or any suitable means the mineral may be roasted, in which operation the water, if present, will be dispelled, the oil will burn out, and the acid will be decomposed and eliminated, in the case of sulphuric acid, which will commonly be used, by conversion into sulphurous-acid gas, which passes off. In case fixed oils are used the mass may be allowed to stand until the water has run off. To hasten the operation of removing the water the mass may be heated, say, to about 212° Fahrenheit or less, whereupon the water will generally be promptly freed and may be poured off or it may be evaporated. The operation of smelting is facilitated by the presence of the fat acting simply as a fuel.

The disposition made of the mineral or metal after concentration, whether by roasting and subsequent smelting or by smelting without previous roasting, or otherwise, belongs to the after treatment and is not material to my present invention.

The proportions in which the acids or salts are added to the oils or fats may vary according to the kind of acid or oil employed, and also according to the kind of ore to be treated; and the manipulation of the substances employed may be varied from that above set forth in either formula given. These matters may be determined in individual cases by the operator; and I do not, therefore, restrict myself to any particular proportions of the substances employed, though I have above indicated proportions of certain acids and oils by one of the other of which practical results may be obtained upon almost all varieties of ores.

It is also not essential to my invention that the acid or salt employed with a vegetable oil be added to the oil before the incorporation of the oil with the ore, as it is entirely practicable, at least in most, and possibly in all, cases, to first mix such oil with the ore and thereafter add the acid, as set forth in the use of petroleum.

I am aware that it has been proposed in a patent to Tunbridge, No. 228,004, dated May 25, 1880, to recover finely comminuted metal held in suspension in water by the use of soap or a saponaceous compound formed by a partial or imperfect blending of an alkali or an alkaline salt with a fat or an oil. The action of the soap or saponaceous compound when diffused through hard water containing the metal in suspension is to form with the lime salt in the water a coagulum in which the particles of metal are enveloped and by which they are held during a subsequent removal of the

water. When the water is soft a lime salt must be added to form the coagulum. I disclaim the use of any substance in connection with the fats and oils capable of saponifying them. I also disclaim the method set forth in said Tunbridge patent as being entirely dissimilar to that herein claimed. Said Tunbridge method is stated in said patent to consist "in first depriving the water of as much earthy non-metallic matter as possible," this being effected by any of the ordinary methods in use for that purpose, such as letting it stand until the earthy matter precipitates. My invention, on the other hand, has reference solely to the separation of metal or metallic mineral from earthy non-metallic matter, (rocky gangue,) and not to its subsequent separation from water. In the practice of my method, moreover, the metal or mineral and non-metallic matter (rocky gangue) are together and in the first instance mixed with the fat or oil, and the non-metallic matter is afterward separated from the metal or mineral by the peculiar action of the acid or soluble neutral or acid salt operating in the presence of water to detach the gangue from the mass.

With the understanding that I am not restricted in the matters mentioned, I claim, broadly—

1. In the separation of pulverulent ores containing rocky gangue, the method of treatment herein described, which consists in mixing with such pulverulent ore a fat or an oil or a constituent thereof, an acid or soluble neutral or acid salt, and water, finally breaking up the mass to allow the sand to separate therefrom.

2. The method, substantially as described, of separating metals or metallic minerals from rock gangues, which consists in mixing a fat or an oil or a constituent thereof with pulverized ore and washing out the gangue with water containing an acid or a soluble neutral or acid salt.

In testimony that I claim the foregoing as my invention I affix my signature in presence of two witnesses.

CARRIE J. EVERSON.

Witnesses:

M. E. DAYTON,

G. F. LANAGHEN.

1101 [DEFENDANT'S EXHIBIT—DRAWINGS AND SPECIFICATION OF LETTERS PATENT No. 373,113, PATENTED NOVEMBER 15, 1887, ISSUED TO H. J. WAGNER.]

(Here follows diagram marked p. 1102.)

1103 United States Patent Office.

HENRY J. WAGNER, of Dayton, Missouri.

Churn.

Specification Forming Part of Letters Patent No. 373,113, Dated November 15, 1887.

Application Filed June 24, 1887. Serial No. 242,412. (No model.)

To all whom it may concern:

Be it known that I, Henry J. Wagner, a citizen of the United States, residing at Dayton, in the county of Cass and State of Missouri, have invented a new and useful Improvement in Churns, of which the following is a specification.

My invention relates to churns; and it consists in the construction and arrangement of parts of the same, which will be more fully set forth hereinafter, and pointed out in the claim.

My present invention relates to an improvement on Patent No. 347,978, granted to me August 24, 1886.

The object of my present invention is to vary the construction of the mechanism shown and described in my patent above mentioned, so as to advantageously provide a churn more positive in its results, cleanly in its operation, simple and effective in its construction, and comparatively inexpensive in its manufacture.

The essential feature of my present invention is the use of suspended dashers devoid of bearing-surface at their lower portions and operated to revolve in reverse directions upon vertically-inclined shafts.

In the accompanying drawings, wherein like letters of reference indicate similar parts in the several views, Figure 1 is a vertical section of my improved churn. Fig. 1 is a top plan view of my improved churn. Fig. 3 is a sectional elevation of a portion of one of the dasher-shafts and its gearing. Fig. 4 is a top plan view of the top bearing-plate.

A indicates the churn-vessel, of suitable size and shape, which is provided with a detachable cover, B, situated on the upper portion of the churn-vessel and having a transversely-arranged metallic plate, D, slotted at its ends to receive the upwardly-projecting spring-plates H′, secured to the vessel A and engaged by the locking-bolts H on the ends of the said plate D. The construction as thus described is common to my patented device aforesaid, and I will now proceed to describe my improvement upon said device.

(No Model.)

H. J. WAGNER.

CHURN.

No. 373,113. Patented Nov. 15, 1887.

Fig. 1.

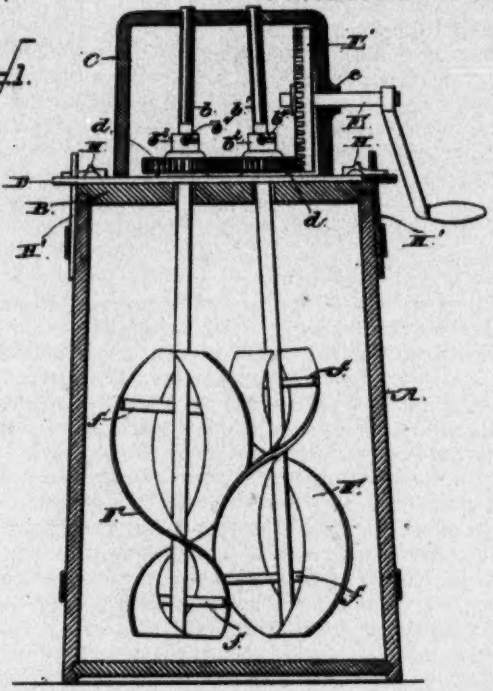


Fig. 2.

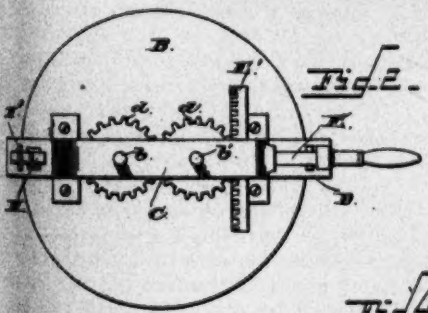


Fig. 3.

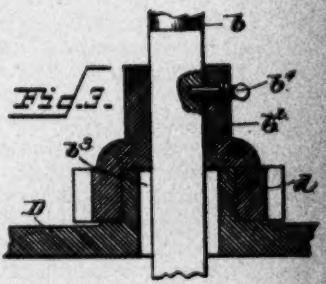


Fig. 4.

Witnesses

Inventor

Henry J. Wagner

Secured to the cover B is a U-shaped bracket, C, closed at its upper side, and at its ends being firmly secured to said cover in any suitable manner. A boss, *c*, is formed in one side of the bracket C, and provides a bearing for a shaft, E, arranged horizontally therein, and having an operating-handle on its outer side; and on its inner end a face-gear, E′, is secured, and arranged in a plane at right angles to the plane of the shaft upon which it is mounted, as will be readily understood.

Two shafts, *b b′*, are vertically mounted in the said frame and at a slight incline to the perpendicular, being loosely secured at their upper ends in the top portion of the bracket C, and having bearing in the boxes b^2 b^2, adapted to fit over flanged openings b^3 in the transverse plate D. The boxes b^2 are formed with apertures, through which spring-pins b^4 engage the shafts, the said shafts being thereby retained in a suspended position. The boxes b^2 are integrally formed with horizontally-arranged spurs or gears *d d*, which rest on the top surface of the transverse plate D and are in mesh with each other and with the vertically-arranged wheel E′ at all times. The shafts *b b′* pass vertically through the blocks b^2 at an incline to the perpendicular and the gears *d*, and are locked in connection therewith, to suspend the same, as desired, by means of the pins b^4, secured to said boxes b^2, and adapted to engage openings formed in the shafts *b b′*, for securing the said shafts, as hereinbefore set forth.

On the lower ends of each of the shafts *b b′* spirally-arranged dashers F F are secured. These spiral blades are mounted in connection with said shafts *b* and *b′* by means of transversely-arranged arms *f*, which extend outwardly and are secured to the back sides of each of the blades or dashers, having the shafts for their centers in connection with each dasher. As seen in Fig. 1, the lower ends of the shafts *b b′* do not touch the bottom of the churn body or vessel A, and have no bearing-points at the lower ends thereof, being braced and supported in the cover B and the bracket C, and having a free suspension within the body of the churn, the lower ends of the dashers being farther apart than the upper ends. These dasher-blades and their shafts *b b′* are adapted to have a reverse revolution. This is accomplished by means of the gear E′ meshing with the
1104 gears *d*, the gear *d* nearest the gear-wheel E′ being revolved in one direction, while the gear *d* on the other side of the first gear *d* is revolved in a reverse direction, as will be readily understood by those skilled in the art.

As hereinbefore set forth, the dasher-blades are formed spirally on two perpendicular shafts turning in opposite directions, giving a slightly angular horizontal circular motion to the dashers, which, crossing each other's circles, the lower ends moving in advance, lift the cream from the bottom, throwing it upward and outward, giving it a semicircular motion, which is continually intercepted in every direction by counter-currents from the oppositely-revolving dashers, causing thorough and equal agitation of the whole mass. In this movement air follows behind and under the blades, and oxygen of the air comes in contact and freely combines with every particle of cream. Thus oxygen combines with sugar of milk, producing lactic acid, which curds the caseine, thus separating it from the butter when

the butter-globules are ruptured by agitation. This advantage will be readily appreciable to those skilled in the art of butter-making, and the advantageous action of the spirally-arranged dashers will be readily apparent in respect to the valuable infusion of oxygen.

In the operation of my improved churn no jarring or plunging motion is heard or felt, the operation being in a measure noiseless.

By the arrangement of the driving mechanism and dashers on the cover B, on removing the said cover to introduce hot or cold water for cleaning purposes all the operating parts are removed at one operation, and on replacing the cover the dasher-shafts will be in adjustment and in proper position without the necessity of any connection or manipulation.

The novelty and utility of my improved churn are apparent, and need not be further enlarged upon herein.

Having thus described my invention, I claim—

In a churn, the body A, having its cover or top provided with a plate, D, the latter having openings b^3 therein, and annular upwardly-extending flanges around the said openings, combined with the shafts *b*, carrying the dashers, the lower ends of the dasher-shafts being entirely disconnected from the body, the upper ends of the shafts being passed through the openings b^3, the gears *d*, recessed in the under side to fit over the flanges of the opening b^3 and turn around the same, said gears being separate from the shafts, boxes b^5, formed integral with the gears, a spring locking-pin, b^4, carried by the boxes to lock the boxes and gears to the shafts, a bracket, C, above the cover to receive the upper ends of the shafts *b*, and the gears *d* meshing with each other and the gear E′ with driving-shaft E, for the purpose set forth.

In testimony that I claim the foregoing as my own I have hereto affixed my signature in presence of two witnesses.

HENRY J. WAGNER.

Witnesses:
LUCY M. WAGNER.
R. D. RAMEY.

No. 259
MINERALS
Separation, Ltd. et al.
v.
HYDE et al.
Page 1106

(No Model.) Sheet 1.

E. A. HOCKLEY.

ORE SLIMER.

No. 466,753. Patented Jan. 5, 1892.

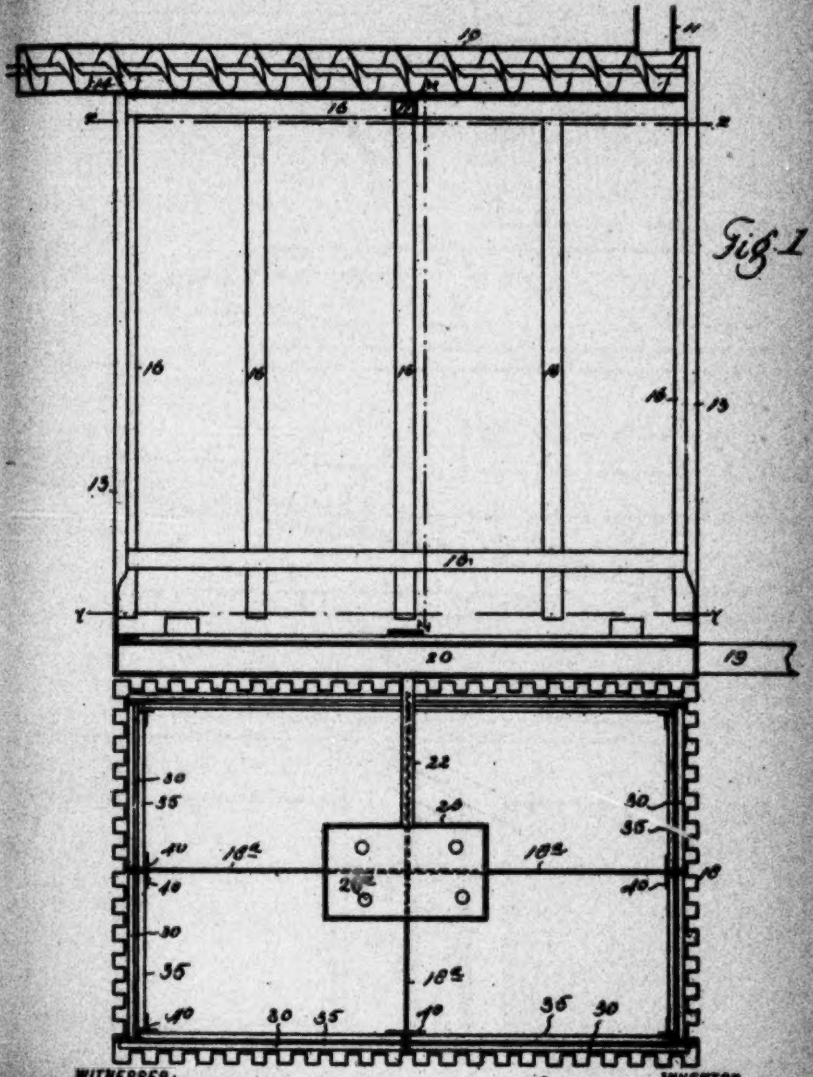


Fig. 1

WITNESSES:
G. J. Rollandet.
[illegible]

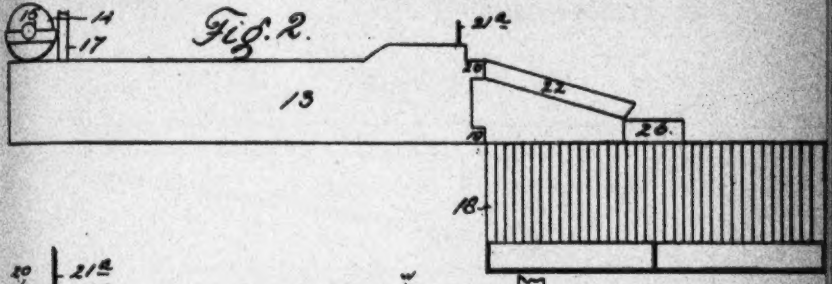
INVENTOR
Edgar A. Hockley
BY [illegible]

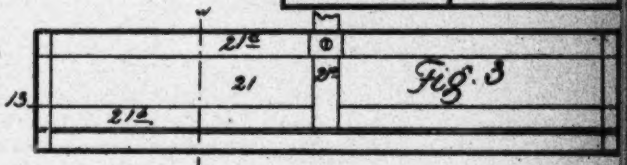
(No Model.) 3 Sheets—Sheet 2.

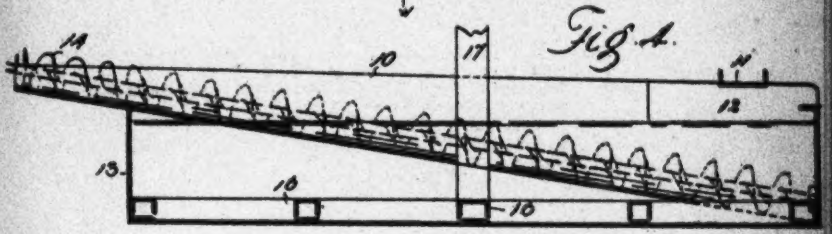
E. A. HOCKLEY.

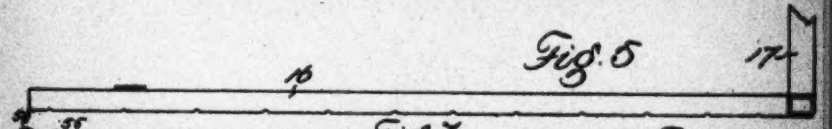
ORE SLIMER.

No. 466,753. Patented Jan. 5, 1892.









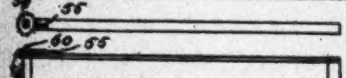
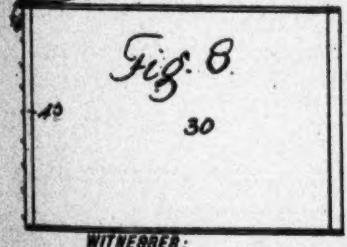
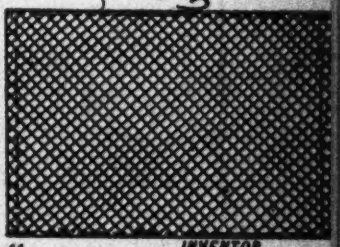


Fig. 7





WITNESSES:
Louis C. P. Wilgus
Wm. McConnell

Fig. 11

INVENTOR
Edgar A. Hockley
BY
A. J. O'Brien
ATTORNEY

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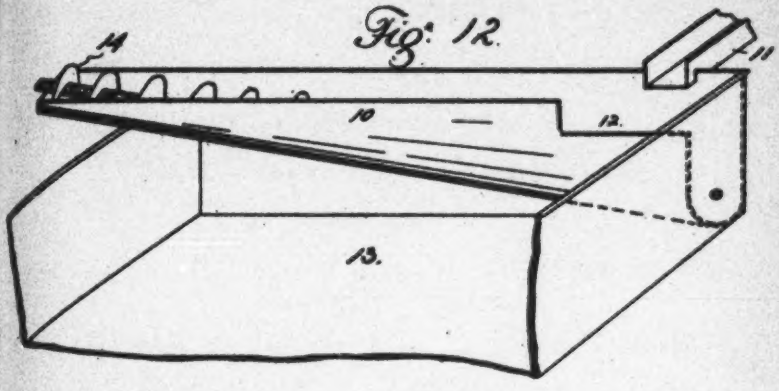
(No Model.)

E. A. HOCKLEY.
ORE SLIMER.

No. 466,753. Patented Jan. 5, 1892.

Fig. 12.



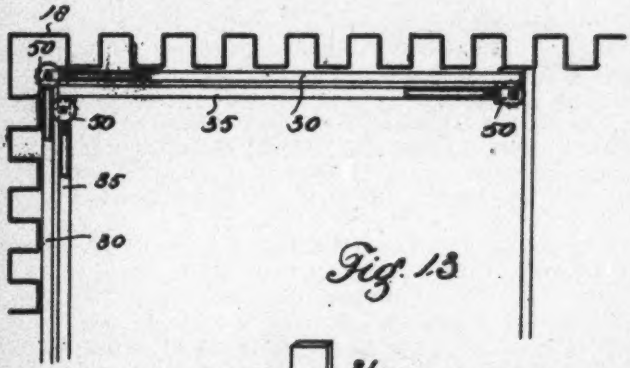


Fig. 13

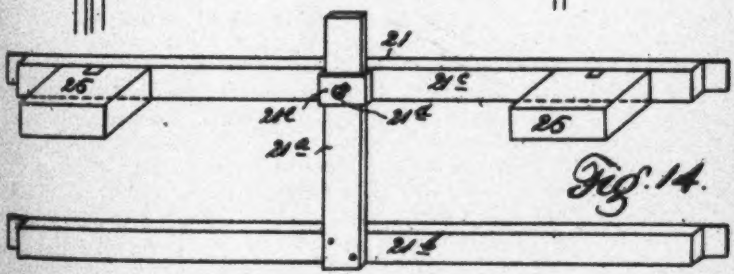
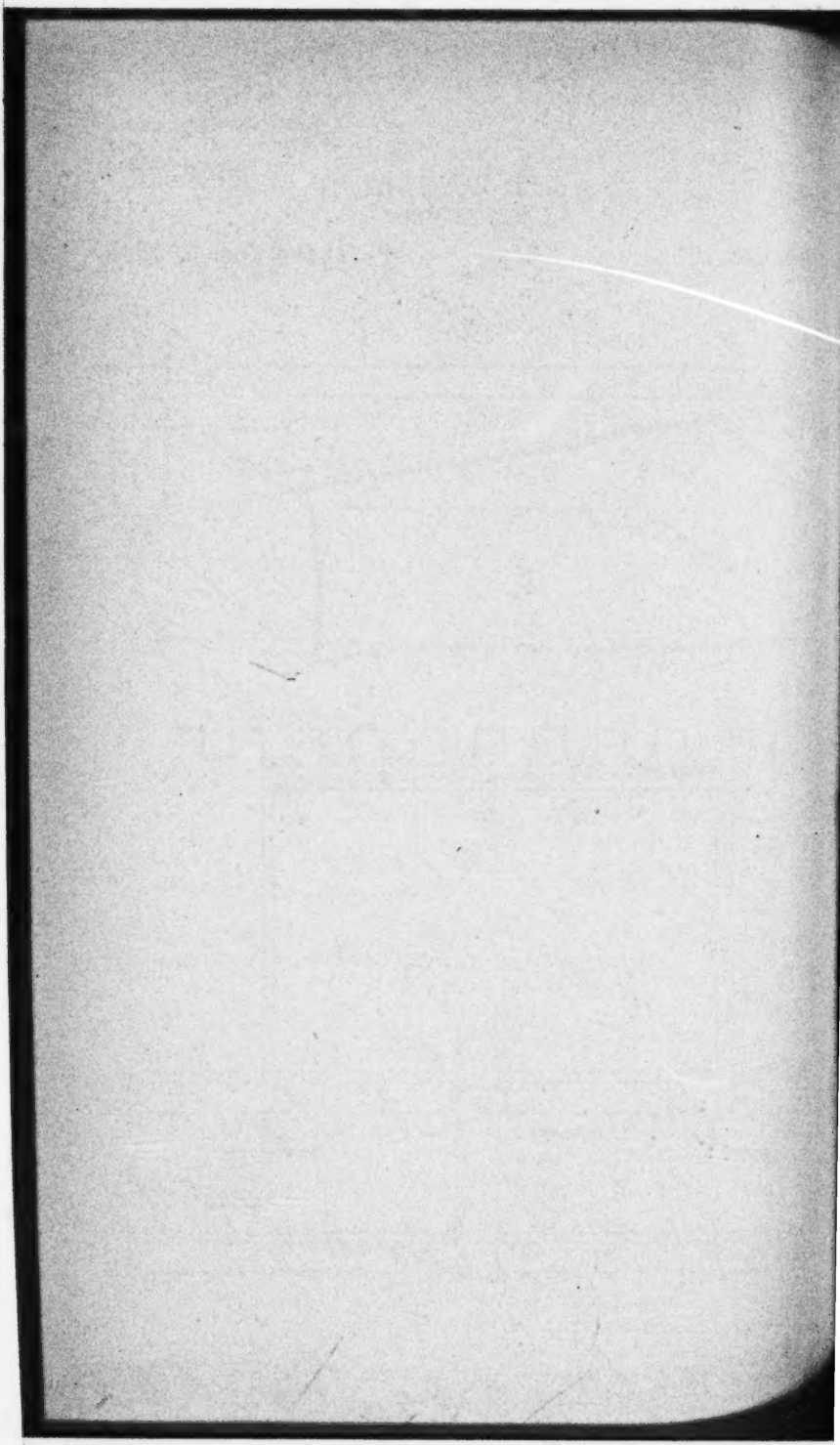


Fig. 14.

Witnesses
J. Rollandet.
Inventor
Edgar A. Hockley
By his Attorney



1105 [DEFENDANT'S EXHIBIT DRAWINGS AND SPECIFICATION OF LETTERS PATENT NO. 466,753, PATENTED JANUARY 5, 1892, ISSUED TO E. A. HOCKLEY.]

(Here follow diagrams marked pp. 1106, 1107, and 1108.)

1109 United States Patent Office.

EDGAR A. HOCKLEY, of Ouray, Colorado.

Ore-slimer.

Specification Forming Part of Letters Patent No. 466,753, Dated January 5, 1892.

Application Filed May 19, 1891. Serial No. 393,346. (No model.)

To all whom it may concern:

Be it known that I, Edgar A. Hockley, a citizen of the United States of America, residing at Ouray, in the county of Ouray and State of Colorado, have invented certain new and useful Improvements in Ore-Slimers; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to the figures of reference marked thereon, which form a part of this specification.

My invention relates to a novel form and construction of mechanism for treating ores, and is designed to save the float mineral, usually called "slimes" and sometimes termed "flour" gold and silver. Whichever term may be employed the meaning is the same to practical miners and to those skilled in the art to which this invention appertains, since these terms are applied to that portion of the mineral which is too light to be saved by the ordinary gravity processes, which depend upon the greater specific gravity of the mineral, which causes the same to settle and separate from the gangue or lighter portion of the material. In all classes of ore there is more or less of this light flour or float mineral, which is held in suspension by the water, while in some kinds of ore this class of mineral amounts to a very large proportion of the value, which is therefore ordinarily lost or carried to the dump with the so-called "tailings."

The object of this invention therefore is to save this light mineral either by the original treatment of the ore or by retreating the tailings which have passed through other machines.

The principle of the invention is to aid or increase the natural floating tendency or buoyant condition of the mineral particles,

whereby the valuable portion is made to float, while the gangue, which is heavier, settles, thus effecting the separation.

My improved mechanism consists of a pulp-box, a separator, and a filtering-tank. The material to be treated is first discharged into the pulp-box, which catches the greater part of the gangue, and is provided with a screw conveyer for removing the same as fast as it settles, the lighter and valuable portion of the mineral passing thence into the separator, into the bottom of which is forced air, steam, water, or other suitable material, producing such an agitation at the bottom as will cause the mineral to float after first separating or washing it from the gangue, when it passes into a filtering-tank, in which the water is drawn off by suitable means, leaving the mineral. This mechanism will be better understood by reference to the accompanying drawings, in which is illustrated an embodiment of the invention.

In the drawings, Figure 1 is a top or plan view of the mechanism; Fig. 2, a side view or elevation of the same; Fig. 3, a section on the line *y y*, Fig. 1; Fig. 4, a section on the line *x x*, Fig. 1; Fig. 5, a section on the line *z z* Fig. 1; Fig. 6, a section on the line *w w*, Fig. 3; Figs. 7 and 8, a top and side view, respectively, of the outer filter; and Fig. 9 a section of the same. Figs. 10 and 11 are a side view and a section, respectively, of the inner filter. Fig. 12 is a perspective view of the pulp-box, showing its connection with the separator-tank, which is partially broken away. Fig. 13 is a top fragmentary view, on an enlarged scale, of the filtering-tank, showing the filtering-walls and the rollers to which they are attached. Fig. 14 is a perspective view of the gate which controls the discharge of the material from the separating-tank.

In the views, wherein similar reference-characters designate corresponding parts or elements of the mechanism, let the numeral 10 designate the pulp-box into which the material to be treated is discharged through chute or spout 11. Enough water is discharged into the box 10 with the ore to float the light and valuable portion of the same, which float material or scum passes through a suitable opening 12 into the separating-tank 13, while the gangue or worthless portion passes to the bottom of the box 10, which is provided with an inclined conveying Archimedean screw 14 for removing the gangue from this box. The bottom of this box is inclined correspondingly with the inclination of the screw. The lower end of this screw is journaled in the receiving extremity of the box, whence the gangue is carried upward the entire length thereof, the inclination of
1110 this screw and the bottom of the box being such that the gangue is above the water-level before it is discharged therefrom. The upper extremity of the screw shaft is journaled in a suitable support and is provided with a pulley 15, by means of which motion may be communicated to the screw from any suitable motor. The screw being in motion, the material in box 10 is kept in a state of continuous agitation, so that as the gangue passes upward toward the discharge extremity of the box the float mineral is washed therefrom and rises to the top in a scum, which passes thence to the separator, as before stated. The size and location of the screw are such that its threads reach close to the sides and bottom of the box, to

which it is enabled to remove the material very clean from the box. A considerable portion of the gangue which is more closely associated with the mineral will find its way to the separator, which consists of a tank of any desired capacity, preferably located contiguous to the pulp-box. In the bottom of this separator is located a series of perforated tubes or conduits 16, all communicating with each other and forming in effect one continuous perforated conduit. One branch of this conduit is in communication with a stand-pipe or upright tube 17, through which air, water, steam, &c., may be forced into tubes 16 and thence into the bottom of the tank for the purpose of agitation, whereby the light mineral is washed or separated from the heavier gangue and an increased upward or buoyant tendency given said mineral, keeping the same upon the surface of the water until discharged into the filtering-tank 18, hereinafter described. At the bottom of the discharge end or sides of the tank is located the lower trough 19 for carrying away the gangue which settles in the bottom of the tank and the upper trough 20, into which the float mineral passes, which collects in the form of a scum upon the surface of the water. The discharge into the troughs 19 and 20 is controlled by the gate 21, consisting of a stem or standard 21^a, centrally located, a lower valve 21^b, rigidly secured to the stem, and an upper valve 21^c, adjustable thereon by means of a set-screw 21^d, which passes through a metal strap 21^e, secured to the valve and through which the stem passes. The valves are simply cross bars or slats centrally connected with the stem and having their extremities guided in grooved ways 40, formed in the sides of the tank. The gate is also provided with one or more floats 25, preferably two, as shown in the drawings. The floats are secured to the upper or adjustable valve in any suitable manner and are designed to rest upon the surface of the water and to regulate the gate automatically and maintain a uniform quantity of water in the separating-tank. For instance, when the proper amount of water is in the tank valve 21^c, with its floats, is set at the proper height—that is, with the floats resting upon the surface of the water—valve 21^b being partly opened or sufficiently so to carry off the surplus-water supply, or that which enters with the material treated. Then if the water-supply is increased the floats will rise and increase the opening below valve 21^b, so as to carry away this increased or excessive supply, while as soon as the supply is diminished the floats lower and partially close valve 21^b. It will thus be seen that this gate is capable of such adjustment that the proper level of the water in the separating-tank may be automatically maintained.

The water and gangue passing through trough 19 may, if desired, be carried or drawn off into any suitable receptacle, whereby they may be allowed to settle in the ordinary way, while the floats or slimes passing into trough 20 are carried by a conduit 22 to the filtering-tank 18. As shown in the drawings, this tank is divided into four compartments by suitable partitions 18^a, which at their intersections in the center of the tank support a box or receptacle 26, into which the material is discharged directly from conduit 22. Receptacle 26 is provided with openings 26^a, adapted to distribute its contents

equally into the compartments of the filtering-tank. It will be observed that the dividing of this tank into compartments is only for convenience and not an essential feature, since it may consist of a single compartment or a plural number, as may be desired. The outer walls of this tank 18 are corrugated, as shown in the drawings, but may be of any construction adapted to permit the escape of the water after having passed through the inner filtering-walls of the tank. The filtering-walls are double and consist of an outer wall 30 and an inner wall 35. These walls 30 and 35 are preferably formed in sections adapted to slide in grooved ways or guides secured to or formed within the outer walls of the tank. The filtering-walls are constructed in any suitable manner, the outer being the finer mesh. A suitable construction for the inner wall 35 is a sheet of asbestus paper placed between two sheets of wire-cloth. The asbestus forms the filter, while the wire-cloth gives it protection and support. The whole is attached to a skeleton frame of suitable strength and composed of any desired material. The outer wall 30 may be composed of filtering-paper secured between two layers of cloth attached to a suitable frame. This cloth is preferably made stationary at one end of the frame and secured to an adjustable roller at the other end. This roller is provided with hooks, to which the cloth may be secured, while the top of the roller is provided with a small ratchet-wheel 50, the teeth of which are engaged by a pawl or dog 55, secured to the upper stationary cross-bar of the frame. It will thus be seen that by placing a suitable crank upon the upper extremity 60 of the roller and turning the same the tension of the cloth forming part of the filter may be adjusted to suit the purpose or the requirements of the case. It will thus be seen that by this construction the mineral will be retained in the tank, while the water is allowed to escape. In cleaning up a portion of this mineral will be found between the filters. This may, however, be easily removed by raising the inner filter and brushing this mineral out into the tank.

1111 & 1112

Having thus described my invention, what I claim is—

1. In an ore separator or slimer, the combination, with a receiving-box provided with an inclined screw conveyer, of a separating-tank provided with perforated tubes located in the bottom or lower portion thereof, a stand-pipe connected with said tubes, a bottom discharge-opening for the tank, and a vertically-movable gate automatically regulated by means of floats, whereby said discharge-opening is controlled, substantially as described.

2. A tank provided with filtering-walls, supported upon suitable frames provided with rollers, the filtering material being made fast to the frame at one extremity and to the roller at the opposite extremity, whereby its tension may be regulated as desired, the roller being provided with suitable locking mechanism, as set forth.

3. A tank provided with double filtering-walls of unequal mesh, each wall being supported upon a frame provided with an adjusting-roller, to which the filtering material is attached at one end, substantially as described.

4. A tank provided with removable filtering-walls, each wall con-

sisting of a frame provided with a roller, and a strip of suitable filtering material made fast to the frame at one extremity and to the roller at the opposite extremity, whereby the tension of the filter may be regulated at will, as set forth.

5. A separator provided with perforated tubes located in the bottom or lower portion of the tank and communicating with each other, a stand-pipe leading to the tubes, a bottom discharge-opening, and a gate provided with floats, whereby said opening is automatically regulated, substantially as set forth.

6. A filtering-tank provided with outer corrugated walls and inner removable filtering-walls provided with rollers for regulating the tension of the filtering material, as set forth.

7. An ore separator or slimer consisting of a receiving-tank provided with an inclined screw conveyer, a separating-tank provided with perforated pipes located at or near its bottom and a stand-pipe connected therewith, said tank being provided with a top and bottom discharge, a vertically-movable gate provided with valves and floats, whereby the discharge of material from the tank is automatically regulated, and a suitable filtering-tank, the three tanks being arranged and connected substantially as and for the purpose set forth.

In testimony whereof I affix my signature in presence of witnesses.

EDGAR A. HOCKLEY.

Witnesses:
W. H. GUBBERT.
L. C. KINIKIN.
W. B. VANATTA.

1113 [DEFENDANT'S EXHIBIT DRAWINGS AND SPECIFICATION OF LETTERS PATENT No. 469,599, PATENTED FEBRUARY 23, 1892, ISSUED TO A. M. ROUSE.]

(Here follow diagrams marked pp. 1114, 1115, 1116.)

1117 United States Patent Office.

ALBION M. ROUSE, of Boulder, Colorado, Assignor to GEORGE R. WILLIAMSON, of Same Place.

Method of and Apparatus for Separating Slime or Fines from Water Used in Milling Ores.

Specification Forming Part of Letters Patent No. 469,599, Dated February 23, 1892.

Application Filed September 29, 1891. Serial No. 407,147. (No Model.)

To all whom it may concern:

Be it known that I, Albion M. Rouse, of the city of Boulder and county of Boulder, in the State of Colorado, have invented a certain new and useful Improvement in Methods and Apparatus for Separating Slime or Fines from Water Used in Milling Ores, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming part of this specification.

My invention relates to an improved method and apparatus for removing or separating slime or fines from water carrying ores; and my invention consists in features of novelty hereinafter fully described, and pointed out in the claims.

Figure I is a vertical longitudinal section of an apparatus embodying my invention. Fig. II is a top or plan view with the cover of the scum-chamber removed. Fig. III is an end view, and Fig. IV is a vertical transverse section taken on line IV IV Fig I.

I will proceed to describe the apparatus with reference to the drawings, which, with the description of the operation of the apparatus, will explain my improved method.

1 represents a suitable frame.

2 represents a pulp-chamber, into which the pipe 3 discharges the tailings from an ore-mill. This chamber has a funnel-shaped bottom 4, terminating in a neck 5, surrounded by a cylinder or wall 6, forming an annular chamber 7. The lower end of the cylinder or annular wall 6 forms the seat 8 of a valve 9, secured to a housing

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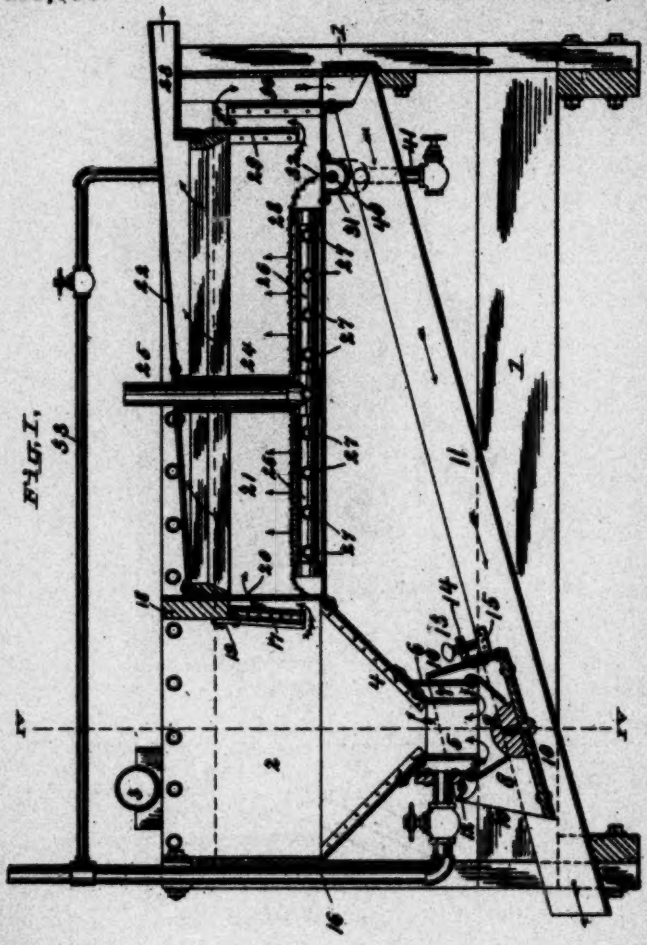
MINERALS
Separation, Ltd. et al.
3 Sheets—Sheet 1.
HYDE.

(No Model.)

A. M. ROUSE.

METHOD OF AND APPARATUS FOR SEPARATING SLIME OR FINES FROM WATER USED IN MILLING ORES.

No. 469,599. Patented Feb. 23, 1892.



ATTEST
A. C. Durand
S. Cotton

INVENTOR
Albion M. Rouse
By Wright Bros

(No Model.) 2 Sheets—Sheet 2.

A. M. ROUSE.

METHOD OF AND APPARATUS FOR SEPARATING SLIME OR FINES FROM WATER USED IN MILLING ORES.

No. 469,599. Patented Feb. 23, 1892.

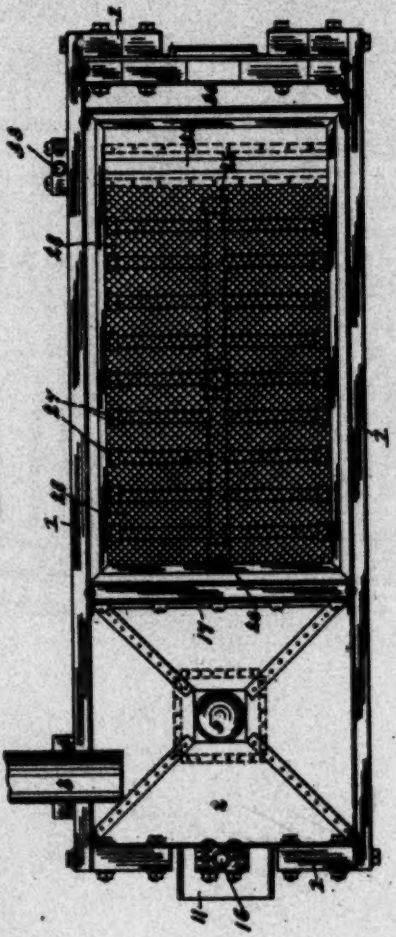


FIG. II.

ATTEST

INVENTOR
Allen M. Rouse
By Wright Brothers
Attys

No. 259
MINERALS
... Ltd. et al. Page 1115

(No Model.) 3 Sheets—Sheet 3.

A. M. ROUSE.

METHOD OF AND APPARATUS FOR SEPARATING SLIME OR FINES FROM WATER USED IN MILLING ORES.

No. 469,599. Patented Feb. 23, 1892.

Fig. III.

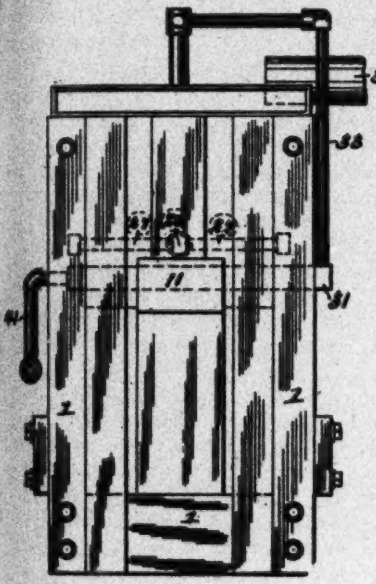
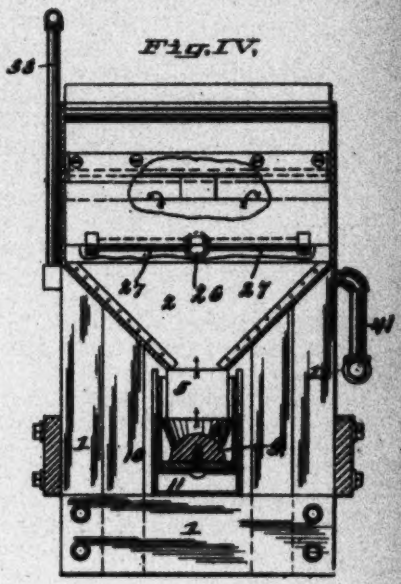


Fig. IV.



ATTEST
A. E. Durand
S. Cotton

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MINERALS
Separation, Ltd. et al.
v.
HYDE.

Page 1116

INVENTOR
Albion M. Rouse
By Wright Bros
Attys

10, located in a trough 11 and pivoted to the frame at 12. The valve 9 is moved to or from its seat by a set-screw 13, passing through a lug 14 on the housing and bearing at its lower end against a cross-piece 15 on the trough 11, so that by turning the set-screw the valve may be moved to or from its seat by adjusting the housing on its pivot 12.

16 represents a water-pipe discharging into the chamber 7.

17 represents a yielding gate secured to a cross-piece 18 of the frame 19 and behind which there is an opening 20 in the inner wall of the chamber 2.

21 represents the slime-chamber having a cover 22 with a discharge-spout 23. The cover 22 has a sleeve 24, which extends downward through the chamber 21 and receives the vertical portion 25 of an air-pipe, on the lower end of which are horizontal pipes 26, having a number of perforated lateral pipes 27.

28 represents a perforated metal or wire mesh screen located over the pipes 26, 27.

29 represents a deflecting-plate at the inner end of the chamber 21 and behind which the waste water passes into a spout 30, which discharges into a trough 11.

31 represents a trough on the under side of the bottom of the chamber 21 and which communicates with the chamber through an opening 32.

33 represents a pipe forming a communication between the pipe 16 and the trough 31, through which water is discharged into the trough to remove the particles which may fall into the trough through the opening 32.

40 is a jet flushing-pipe in the trough 31 to promote action of the parts precipitated. 41 is a discharge-pipe from the trough 31.

The operation of the device or apparatus is as follows: The mill-tailings drop from the pipe 3 into the chamber 2. Water from the pipe 16 enters the chamber 7, the greater portion of it passing up through the neck 5 into the chamber 2, as shown by the arrows, while a smaller portion passes around the valve 9 and escapes into the trough 11. The up-current is rapid enough to prevent the descent of the slime-water in chamber 2 and carries the slime-water up behind the gate 17 through the opening 20 into the chamber 21 and along the chamber over the pipes 26 27. The waste water then passes up behind the deflector 29 into the spout 30 and is discharged through the trough 11 to the dump. As the slime-water passes slowly through the chamber 21 it is acted upon by an innumerable number of air-bubbles escaping from the perforate pipes 26 27, into which the air is forced through pipe 25. The constant upward circulation of air through the slime-water tends to elevate all foreign matter to the surface of the water and to create or form a mass of strong foam having a great carrying energy for matter foreign to water. As the foam accumulates in the chamber 21 it is forced out through the passage 23 to a drier.

By means of this invention valuable mineral slime or fines
1118 may be saved which have heretofore been lost.

I claim as my invention—

1. The improved method of separating mineral slime or fines, consisting in discharging air beneath the body of slime and causing it to be emitted and permitted to pass upward through the slime, forming a foam, substantially as set forth.

2. The improved method herein shown and described, consisting in depositing the mill-tailings into a receptacle through which there is an upward flow of water, then carrying the water and tailings through a chamber, and causing an upward flow of air through the body of water and tailings, forming a scum, substantially as and for the purpose set forth.

3. The combination of the chambers 2 and 21, an air-pipe 25, having perforated branches for the escape of air, a screen over said branches, and a separate escape for the waste water and scum formed by the passage of the air through the mass, substantially as and for the purpose set forth.

4. The combination of the chamber 2, having a neck 5, a wall 6, forming a chamber 7, the valve 9, secured to an adjustable housing 10, the pipe 16, the gate 17, a chamber 21, having a cover 22, a pipe 25, having perforated branches, a screen 28, a trough 31, communicating with the chamber 21, pipes for cleaning the trough, a deflector 29, spouts 23 and 30, and a trough 11, substantially as and for the purpose set forth.

ALBION M. ROUSE.

In presence of—
JOHN P. HALDEMAN.
C. C. HALDEMAN.

(No Model.) 3 Sheets—Sheet 1.

112

C. B. HEBRON & C. J. EVERSON.

PROCESS OF CONCENTRATING ORES.

No. 471,174. Patented Mar. 22, 1892.

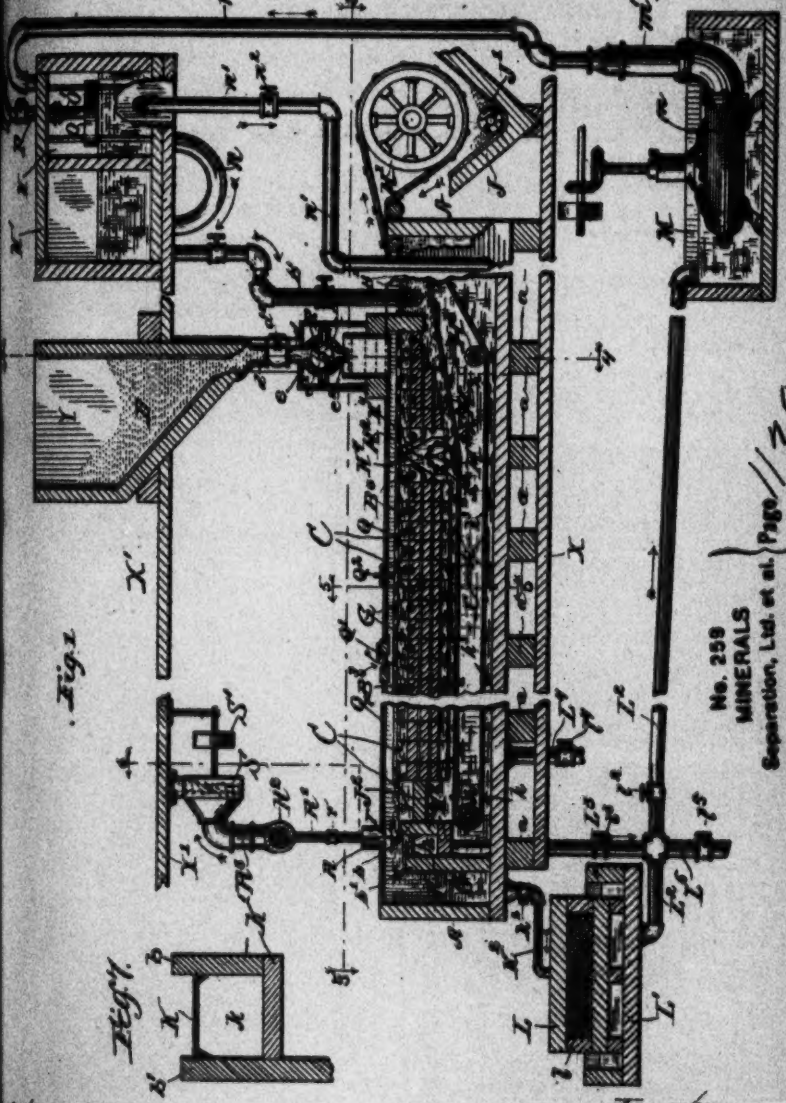


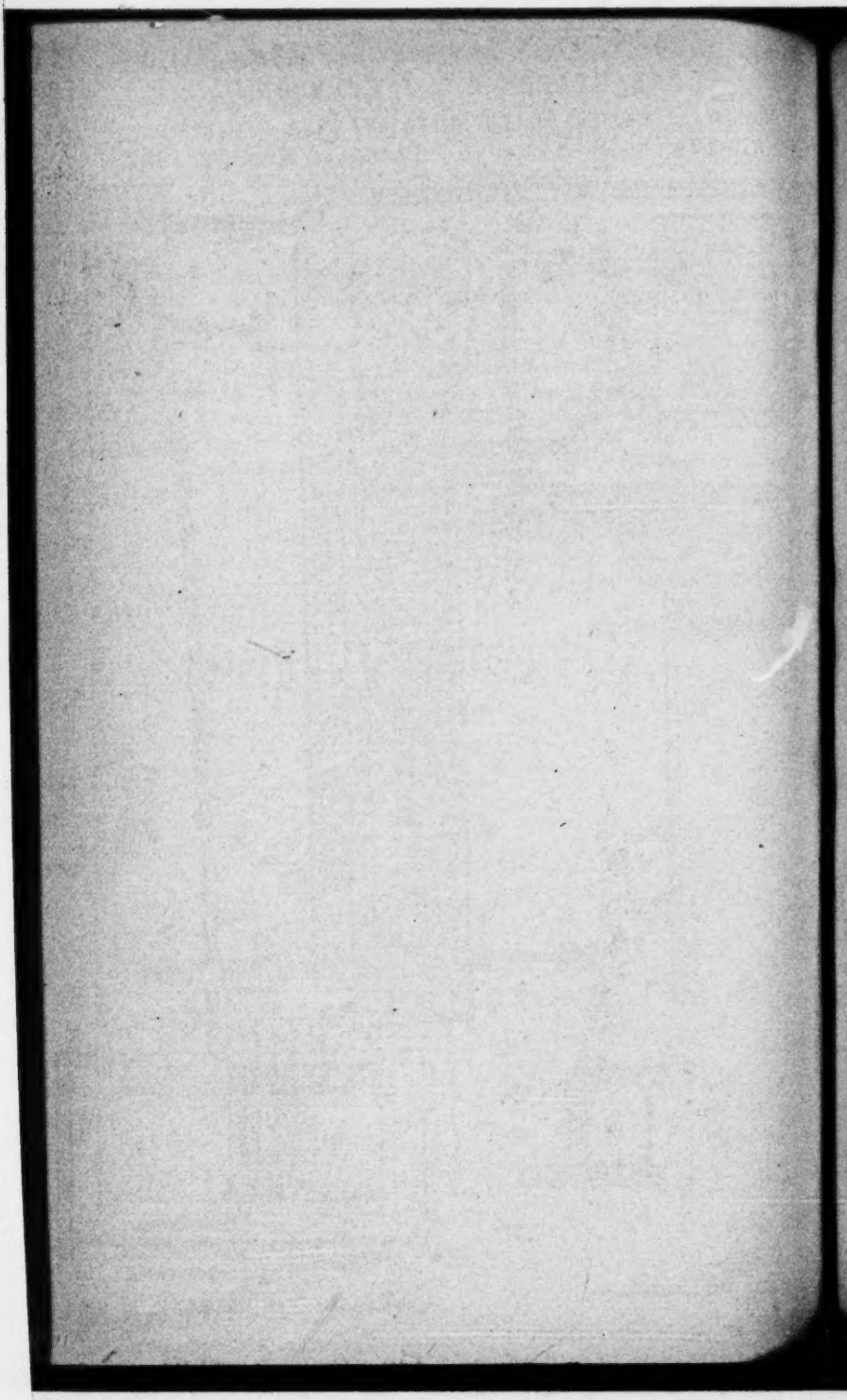
Fig. 1.

Fig. 4.

No. 259
MINERALS
Separation, Ltd. et al.
v.
HYDE.
Page 110

Witnesses:
[illegible]

Inventors:
Charles B. Hebron
Carrie J. Everson
By Charles F. Brown, Atty.



No. 259
MINERALS
Separation, Ltd. et al.
3 Sheets—Sheet 2.

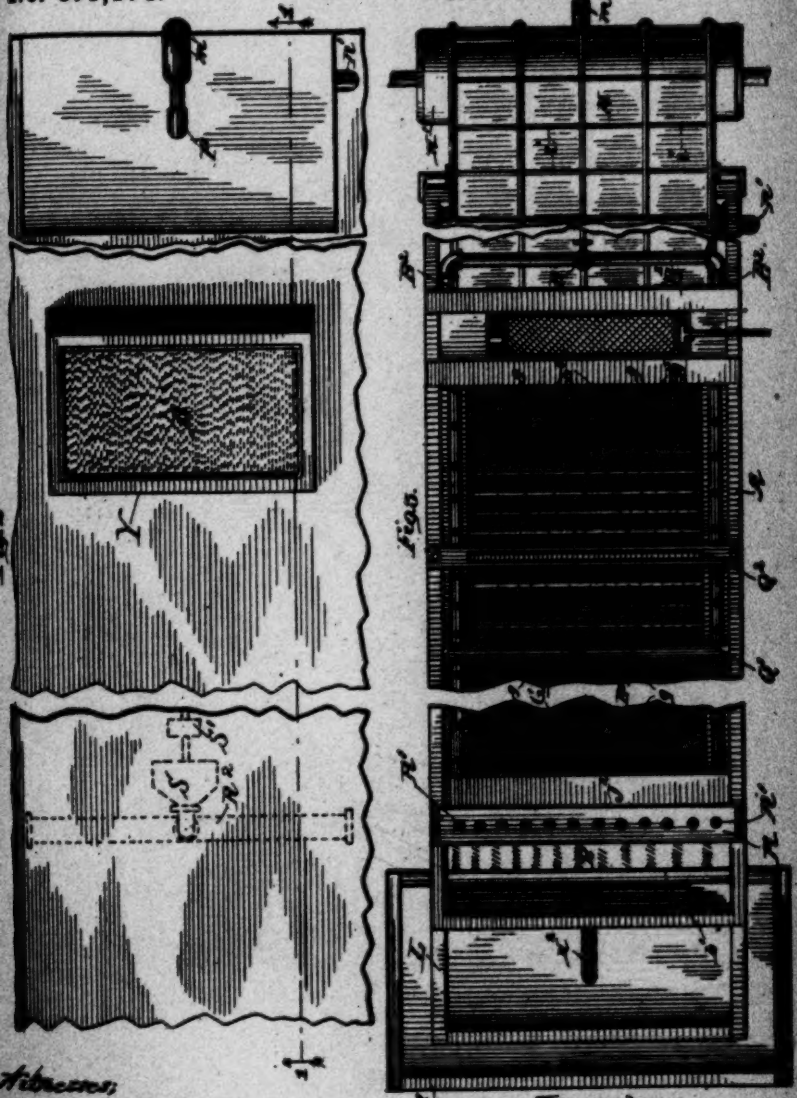
Page 1121

(No Model.)

C. B. HEBRON & C. J. EVERSON.

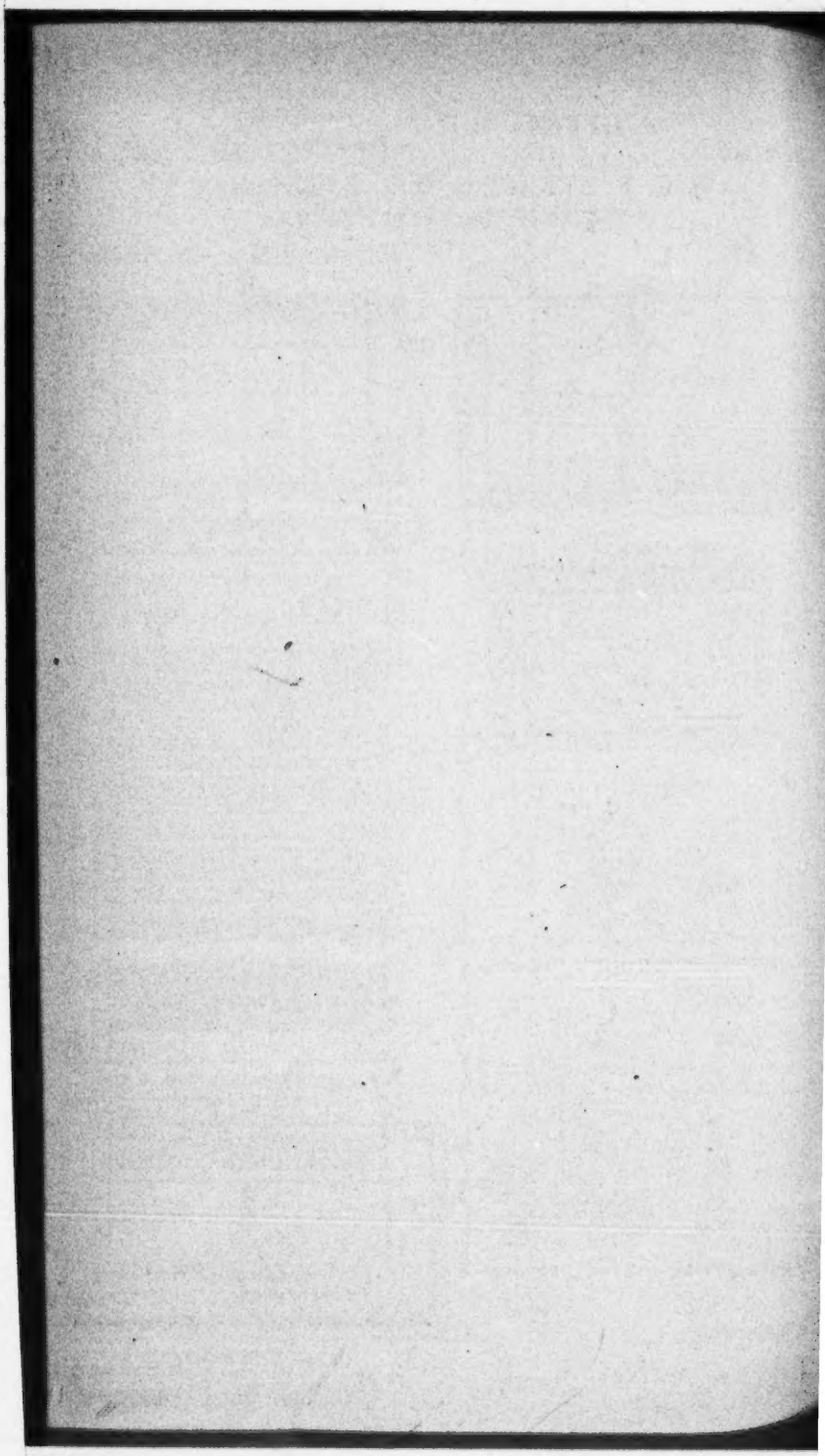
PROCESS OF CONCENTRATING ORES.

No. 471,174. Patented Mar. 22, 1892.



Witnesses;
Lieta S. Alter
Flora L. Brown.

Inventors;
Charles B. Hebron and
Carrie J. Everson,



(No Model.) 3 Sheets—Sheet 3.

C. B. HEBRON & C. J. EVERSON.

PROCESS OF CONCENTRATING ORES.

No. 471,174. Patented Mar. 22, 1892.

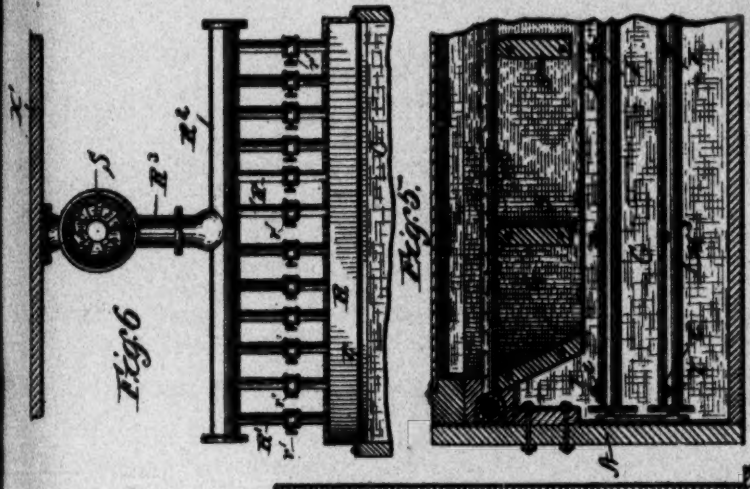


Fig. 6.

Fig. 5.

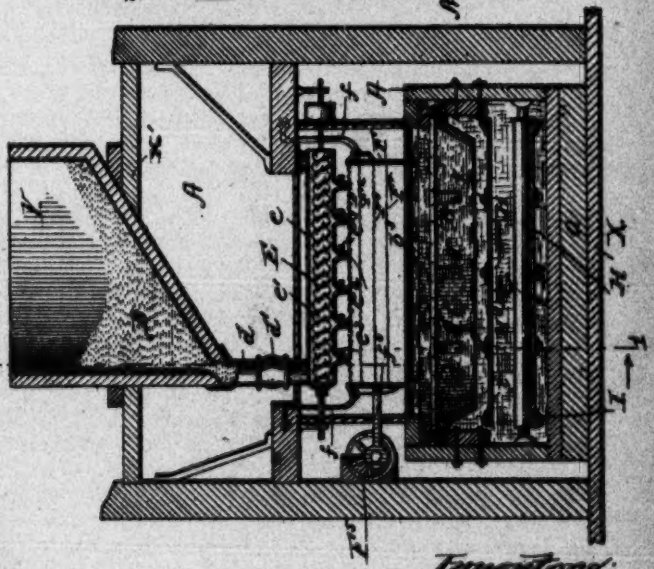


Fig. 4.

Witnesses;
Lutz B. Altar
Thos. L. Brown.

Inventors:
Charles B. Hebron
Carrie J. Everson:
By Charles T. Brown,
Atty.

MINERALS Separation, Ltd. et al. v. HYDE. Page 1122

1119 [DEFENDANT'S EXHIBIT—DRAWINGS AND SPECIFICATION OF LETTERS PATENT No. 471,174, PATENTED MARCH 22, 1892, ISSUED TO CHARLES B. HEBRON ET AL.]

(Here follow diagrams marked pp. 1120, 1121, and 1122.)

1123 United States Patent Office.

CHARLES B. HEBRON and CARRIE J. EVERSON, of Denver, Colorado.

Process of Concentrating Ores.

Specification Forming Part of Letters Patent No. 471,174, Dated March 22, 1892.

Application Filed September 1, 1891. Serial No. 404,400. (No Model.)

To all whom it may concern:

Be it known that we, Charles B. Hebron and Carrie J. Everson, both residents of Denver, in the county of Arapahoe and State of Colorado, have made new and useful Improvements in Processes for the Concentration of Certain Ores; and we do declare the following to be a full, clear, and exact description of the invention, such as will enable those skilled in the art to which it appertains to practice the same.

Our invention relates to the concentration of ores, and has for its object the successful and economical separation of the lighter metals and minerals from their associate rock, many of which have never heretofore been successfully separated by mechanical processes—that is, processes wherein the relative specific gravity of the ore values, the rock-matrix of the ore, and the suspensive fluid in which the separation has been attempted have been relied upon for effecting by means of many different mechanical appliances the desired separation of such values from the rock-matrix of the ore.

The failures resulting from the heretofore-known processes may be briefly stated to be due to the effect of inventors of mechanical processes and builders of ore-separators to obtain the desired concentration with processes and machines based upon the theory contained in the statement by text authorities that all metals and minerals are of greater specific gravity than the rock portion of their respective ores, such statement being misleading and untrue because of the porosity of structure and irregularity of form which exists in metallic and mineral particles contained in certain ores whereof the rock-matrix is crystalline, such rock particles having smooth and [illegible] surfaces, as we have discovered by an extended series of micro-

scopical examinations, wherein the ore examined has been first pulverized to a degree of fineness permitting it to pass through the meshes of a series of Swiss bolting-cloth screens of a mesh varying from one hundred to one hundred and eighty meshes per linear inch and then examining the mineral, metallic, and rock particles of the ore with a microscope producing an enlargement of at least three thousand diameters, and the process embodying our invention has particular reference to the separation or concentration of such ores.

The form and structure of the mineral and metallic particles adapted when contained in a suitable crystalline rock-matrix to be separated by our process is amply illustrated and particularly noticeable in bismuth, silver, copper carbonate, silver chloride, gray copper, ruby silver, tellurides, copper and silver glances, as well as other forms of black sulphurets, wire silver, nearly all native silver, flake and flour gold, and frequently coarser particles of free gold, such mineral and metallic particles being irregular in form, with cavities or depressions on the surfaces thereof, and porous in structure, frequently resembling in appearance coral or sponge or vegetable fibers, as sprigs of moss or segments of fronds. Further, there is a type of ores made up of an argentiferous class of minerals associated with a tough crystalline rock, especially noticeable in spargangue carrying gray copper, in which the mineral does not exist in minute particles or in intimate dissemination through the rock, but in coarse particles widely separated from each other and of an extremely rigid though friable texture, for the concentration of which our process is well adapted. In the operation of pulverizing this ore sufficiently to liberate the mineral contained therein, though only a coarse pulverization is required, the mineral becomes reduced to an almost impalpable slime, the particles thereof being sufficiently fine for the requirements of this process. We have also discovered that the buoyancy of the above-named minerals and metallic particles or the tendency of such particles to remain suspended in fluid may be so increased by applying thereto properly-prepared buoyant material in a suitable way and under such pressure as to cause particles thereof to adhere to the irregular surfaces and to be contained or pressed into the cavities or pores of such mineral and metallic particles that they will not only remain suspended in fluid for much longer time than would the mineral and metallic particles when not joined to particles of buoyant material, but also to float upon the surface of liquid for a sufficient time to be separated from the rock-
1124 matrix of the ore by such rock-matrix settling through such liquid. In practicing this invention such properly-prepared buoyant material is evenly distributed with the ore particles by means of shaking or revolving screens or of equivalent mechanical devices, and the mixture so obtained is then submitted to a rubbing movement and pressure, the result being that the particles of buoyant material are pressed into the cavities and pores, or partially so, of the mineral and metallic particles and made to adhere to the rough and irregular surfaces thereof, and they (the joined mineral and me-

tallic particles of the ore and buoyant material) are of less specific gravity for a time than the rock particles of such ore.

We have found ordinary mill-burrs to be effective in the operation of attaching the particles of buoyant material to the metallic and mineral particles of disintegrated ore.

The amount of buoyant material to be added to a given quantity of pulverized ore must be determined by the bulk of the metal or mineral contained in such ore. Experience has shown us that if the amount of foreign buoyant material added to the disintegrated ore be equal to or slightly in excess of the bulk of metal or mineral contained in such ore a sufficient buoyancy will thereby be imparted to the metal and mineral particles after thus joining to admit of their obtaining the upper strata when such prepared ore-stock is submitted to stratifying agencies.

The following list comprises a number of materials which are typical of the substances that may be employed to render metallic and mineral particles buoyant: Charcoal, coke, lamp-black, plumbago, any of the friable vegetable fibers—such as bark, moss, straw, cotton, wool—also sulphur, (sublimed,) aluminum trihydrate, hydrated lime sulphate, sodium oleate and other cheap salts of sodium, also the cheap metallic sulphates and oleates. These salts must be dry not only in the ordinary sense, but entirely dehydrated, so as to render them amorphous. The carbonaceous substances are first named because of their cheapness, their positiveness of action, and their destructibility in the furnace. Sulphur also acts as a fuel and in the free state and proper quantity for carrying out the process would be unobjectionable to the smelter. Lime salts acting as oxidizing fluxes need no consideration, nor do the soluble salts, as they are easily removed from the concentrates before smelting. In operating with soluble salts the water employed in the separator-tank, hereinafter described, must be saturated either with the same salt or with one which will preserve the same conditions—that is, remain incapable of dissolving or reacting chemically upon the salt mixed with the ore and attached to the metallic and mineral particles thereof. To this rule we make certain exceptions—to wit, cases where the newly-formed substance is able to take the place of the one destroyed, as in the case of sodium oleate reacting to form oleic acid or any other oleate or in the case of common alum acting to form aluminium hydrate.

The terms "oleic acid" and "oleate" are here used to embrace the mixed fatty acids and their salts resulting from the decomposition of commercial soaps.

The degree of fineness to which the ore must necessarily be pulverized before the "buoy-stock" (as we shall hereinafter term the buoyant material) is joined thereto is determined by the character of the ore and the manner in which the mineral and metallic particles are disseminated in the rock-matrix of the ore.

While some of the lighter class minerals are found sparsely and intimately disseminated with the rock-matrix of their respective ores and the particles of minerals so minute as to require a pulverization which is commercially impracticable, yet in nearly all cases where

the metallic and mineral particles are found in a crystalline rock-matrix constituting an ore otherwise suitable for separation by our process we have found that a pulverization of from ninety to one hundred and sixty mesh, such pulverization being eminently practicable, effectually pulverizes the ore to a degree of fineness which liberates the values from their envelopment.

In cases where vegetable fiber or any of the carbonaceous substances are used as a buoy-stock they, together with the disintegrated ore, must be dry before the two are mixed preparatory to the joining of the metallic and mineral particles to and with the buoy-stock. In cases where the chemically-prepared buoy-stock is used the ore and the buoy-stock may be mixed or distributed together in the presence of moisture; but the operation of attaching the buoyant material to the metallic and mineral particles of the ore must be performed after the entire mass thus distributed together has been thoroughly dried.

As our process is only adapted to separate the metallic and mineral particles from a crystalline rock, (an ore with a rock-matrix of crystals, as a pure and translucent quartz, or a crystalline spar-gangue being particularly favorable,) no trouble arises in attaching the buoyant material to the metallic and mineral particles of the pulverized ore from any tendency of the buoyant material to adhere to the surface of the rock particles, as the faces of the rock particles are smooth and glassy and offer no position of lodgement for such buoyant material.

We do not claim any value for this process if it be applied to an ore with a talc or clayey gangue, or, except for the separation of the lighter mineral and metallic particles, when applied to an ore containing galena or pyrites of cubical formation.

When ores adapted for treatment by this process are pre-
1125 pared in the foregoing manner, a separation may be effected with more or less perfection if the thus-prepared stock be submitted to any of the standard dry or wet concentrators. In case a dry separator be used the buoyed values of the ore-stock will attain the position reached by the gangue when the conventionally-prepared ore-stock is put in the machine, and the rock particles will be delivered to the position that the product is delivered in such cases, and if the ore-stock prepared by our method is delivered by means of sifting or blowing to the surface of the water contained in or upon wet concentrators the reverse of position to that of the product and waste of the ordinarily-prepared ore-stock in the use of the machine is attained by the product and the waste. Repeated experiments have proven to us that the standard concentrators in use—such as air-jigs, oscillating tables, wet jigs, frue vanners, or percussion-tables—may be adjusted to admit of a fairly good separation; but there are mechanical barriers to the perfect separation, or, more particularly, to the rapid and economical operation of the same. Therefore we submit a description of a device, the invention of Charles B. Hebron, peculiarly suited to the successful operation of separating the buoyed values from the rock particles of the ore-stock as prepared in the hereinbefore-described manner and an illustra-

tion of such device in the drawings accompanying and forming a part of this specification, in which—

Figure 1 is a longitudinal sectional view of a liquid-separator on line 1 1 of Fig 2, viewed in the direction indicated by the arrows; Fig. 2, a plan view; Fig. 3, a horizontal sectional view on line 3 3 of Fig. 1, viewed in the direction indicated by the arrows, the top of the tank of the separator being transparent and so exposing to view the several parts contained in the tank; Fig. 4, a vertical cross-section on line 4 4 of Fig. 1, viewed in the direction indicated by the arrows; Fig. 5, a vertical cross-section, on an enlarged scale, of a portion of the device on line 5 5 of Fig. 1, viewed in the direction indicated by the arrows; Fig. 6, a vertical cross-section on line 6 6, Fig. 1, also viewed in the direction indicated by the arrows; and Fig. 7, a detail view of the foraminated plate (illustrated in Fig. 1) near the tail end of the tank of the separator, and hereinafter termed a "perforated table."

The same letter of reference is used to indicate a given part where more than one view thereof is shown.

X X′ are floors of the building in which the separator is placed.

Y is the storage for the ore-stock which is to be run through the separator.

A is a tank adapted to hold liquid, constructed of any suitable material, but preferably of wood, and rectangular in shape, with its greatest length from the head to the tail.

a a are timbers resting on the floor X, extending transversely across between the tank A and the floor X, on which timbers the tank rests.

The liquid contained in the tank, preferably water or brine—that is, water saturated with common salt—is supplied thereto through the pipe B at the head end of the tank and is ultimately discharged over the bridge walls or partitions *b b′* at the tail end of the tank. Such liquid is lettered C. The pipe B extends downward to underneath the surface of the liquid C in the tank and at its lower end is connected with a series of horizontal pipes consisting of transverse pipe B′, longitudinal pipe B^2, and smaller transverse pipes B^3 B^3.

b^3 b^3 are perforations on the upper half of each of the transverse pipes B^3 B^3, through which the liquid C enters the tank, there being sufficient head in the pipe B to force the liquid out of the perforations in a manner to produce a slight effervescing condition in such liquid directly over such perforations.

D is the ore-stock, properly prepared, contained in the storage Y.

d is a pipe having valve *d′* therein, extending from storage Y to transverse conveyer E. Conveyer E consists of tube or trough *e* and conveyer-screw *e′* nipples e^2 e^2, extending downward from tube or trough *e*, and valves e^3 e^3 in such nipples.

e^4 is a driving-pulley on the shaft of the conveyer-screw by which such conveyer-screw is turned.

F is an oscillating frame suspended on vibratory arms *f f*, adapted to be rapidly moved a slight distance backward and forward or oscillated by the cam-wheel F^5 through connecting-arm f^5.

F^6 F^6 F^6 F^6, respectively, are screens in frame F, forming a series

of screens through which the ore-stock D, delivered from the nipples e^2 e^2 on the upper one thereof, passes just prior to its delivery to the surface of the liquid C in the tank A.

The purpose of the several mechanisms between the storage Y and the tank A is to insure the taking of the prepared ore-stock D from such storage and the delivery of the same to the surface of the liquid C in the form of a dust-cloud, whereby a thin surface charge of prepared ore-stock shall be obtained on the liquid C, near the head of the tank A, underneath the lower one of the screens forming the series. The ore-stock thus delivered to and contained on the surface of the liquid C in the tank A and consisting of the pulverized and buoyed values and the pulverized rock matrix or gangue are separated from each other in the tank, the purpose of the several mechanisms contained in the tank being to so separate the buoyed values in such ore-stock from the gangue thereof and to deliver such buoyed values at or near the tail end of the tank and to deliver the gangue of the ore-stock from the head end of the tank.

G G G are vertical partitions extending transversely across
1126 the tank, the upper edge of each partition being a slight distance below the surface of the liquid C and the lower edge a short distance above an endless apron-belt, by which apron-belt the gangue settling through the liquid is carried from the tank.

g g are braces extending between partitions G G, respectively.

H is such endless apron-belt having taut cleats *h h h* thereon and longitudinal ropes I I fastened thereto by the straps *i i*, such straps being, preferably, sewed to the belt H. Apron-belt H extends longitudinally through the tank and out therefrom over the edge of the head end thereof, and from thence over the drum H′, by which drum it is moved.

The upper and carrying portion of the apron-belt H for the greater part of the length thereof is substantially horizontal, being held in position at the point of junction of the horizontal part extending along in the tank with the inclined part extending out of the tank over the edge of the head thereof by the sprocket-reel H^3, having projections h^2 h^2 thereon, and the horizontal position of the remainder of the carrying portion of the belt is obtained by such apron-belt extending around the roller or drum *h′* and idlers h^3 h^3. The lower or ingoing portion of the endless apron-belt is held in place by the roller or drum H^3. To prevent any possible disturbance of the surface of the liquid C by the movement of the sprocket-reel H^3 there is placed over it the housing H^4,

J is a spout or trough underneath the drum H′, adapted to receive the gangue delivered from the endless apron-belt H as such belt travels around the drum H′, and J′ is a common screw conveyer by which the spout or trough J is emptied.

J^3 is a horizontal planking forming a cover for the endless apron-belt at the tail end of the tank and also forming on the opper surface thereof a horizontal bed by which, from inspection of the settlings thereon, if any, the presence of gangue in the liquid about to pass over the bridge-wall *b* can be determined.

K is a perforated table forming a sieve, through which the greater

part of the liquid passing over the bridge-wall *b* can pass into chamber *k*, such chamber *k* being formed by planking K′ and bridge-walls *b b′*. The liquid passing over the bridge-wall *b′* carrying on the surface thereof the buoyed mineral and metallic particles from the ore-stock, flows through the pipe K^2 into receptacle L.

l l are screens in receptacle L, through which the liquid passing into such receptacle can pass into receptacle L′, thereby leaving the buoyed mineral and metallic particles in the receptacle L, from which they are take to be afterward treated in any desired manner.

L^2 is a pipe extending from receptacle L′ to and communicating with receptacle M, and l^2 is a valve in pipe L^2.

L^3 is a pipe which extends from chamber *k* to pipe L^2 and is joined to pipe L^2 by means of a common T-joint, and pipe L^5 extends from pipe L^2, forming a continuation of pipe L^3.

l^5 is a valve in pipe L^5.

When valve l^2 in pipe L^2 or valve l^5 is open and valve l^3 in pipe L^3 is also open, the liquid in chamber *k* can pass therefrom through the pipe L^3. The proportion of the liquid passing over the screen K which is permitted to pass through such screen into chamber *k*, and from thence through pipe L^3, is determined by the valve l^3, and the direction such escaping liquid flows is determined by the valves l^2 and l^5, respectively—as, for instance, closing valve l^5 and opening valve l^2 guides the liquid into a receptacle, from which it is returned, by means hereinatfer described, to the storage-reservoir, from which the pipe B extends, and opening the valve l^5 permits the liquid to flow to waste.

When it is desired to empty the tank A of the liquid contained therein without allowing such liquid to pass over the bridge-walls *b b′* as for cleaning out the tank or flushing it, the valve l^4 in pipe L^4 is opened; but ordinarily valve l^4 is maintained in a closed condition.

m is a centrifugal pump in receptacle M, and *m′* is a pipe from the centrifugal pump *m* to the tank N. The liquid flowing into receptacle M through pipe L^2 is forced by the pump *m* into tank N through pipe *m*.

O is a float-valve in tank N, and O′ is the stem thereof, adapted to close the pipe P (such pipe P extending from a liquid-supply) when the liquid contained in the tank N is raised a determined amount and to open such pipe when less than the determined amount of liquid is contained in such tank. By means of this valve O the pipe P when the liquid returned to the tank N through the pipe *m′* is insufficient to maintain the desired height of liquid in tank N the additional liquid required is automatically supplied through the pipe P.

N′ is the liquid-storage tank from which the liquid is taken through the pipe B to supply the tank A, and *n* is a pipe connecting the tank N with tank N′. The use of pipe *n* is to prevent any pulsation in tank N′ from the movement of the centrifugal pump M or the water passing therethrough into tank N.

In order to supply liquid directly to tank A from tank N, as in the case of desiring to flush the bottom of the tank A, supply-pipe *n′*,

having valve n^2 therein, is connected at its upper end with the storage-receptacle N and at its lower end with the tank A.

Q is the cover of the tank A, and Q′ is a slide in cover Q, which can be moved to produce an opening of any desired size in the cover Q.

Q^2 is a partition extending transversely across the tank A from the cover Q to near the surface of the liquid C in the tank.

1127 The slide Q′ and the partition Q^2 are adjustable, the joint functions of the two being to determine the quantity of air drawn through the tank by the fan S and its source—that is, when the slide Q^2 is near the surface of the liquid C in the tank and the slide Q′ is opened widely nearly all the air passing through the tank will pass through the opening covered by the slide Q′, and a small portion thereof will be supplied underneath the slide or partition Q^2, while a larger quantity of air will pass under the partition Q^2 if such partition be raised farther away from the liquid C. The partition Q^2 has another function—namely, to deflect all, if any particles of ore-stock floating above the liquid C (in the air between the surface of liquid C and cover Q) downward to the surface of such liquid as it passes underneath the slide Q^2.

R is a chamber extending transversely across the tank near the tail end thereof, and *r* is a perforated screen between the chamber R and the tank A.

R′ R′ are a series or pipes extending from the chamber R to the transverse pipe or conduit R^2, and *r′ r′* are valves in pipes R′ R′, respectively.

R^3 is a pipe extending from the transverse pipe R^2 to and communicating with the exhaust-fan S.

S′ is the driving-pulley by which the exhaust-fan S is rotated.

When the exhaust-fan S is in operation and the slide Q′ in cover Q is open, a current of air will extend from the slide Q′ over the surface of the liquid contained in the tank, and from thence through the screen into the chamber R, and from thence through the several pipes R′ R^2, and R^3 to and through the exhaust-fan S. By means of the series of valves *r′ r′* and the screen *r* the amount and direction of the moving current of air can be definitely determined, it being understood that the opening of the slide Q′ is properly adjusted for the amount of current desired.

In the operation of this device the liquid entering the tank A through the perforations b^3 b^3 in pipes B^3 B^3 flows over the top of the partitions G G G along toward the tail end of the tank and over the bridge-wall *b*, an effervescing movement being produced, as hereinbefore described, in the liquid C over the perforations b^3 b^3 b^3 and a wave-like movement being produced the entire length of the tank by the partitions G G G. The buoyed mineral and metallic particles of the ore-stock will be found floating in the form of a scum upon the surface of the liquid along with such liquid toward the tail end of the tank, and when the exhaust-fan S is in operation the wave-like movement of the surface of the liquid is increased and a movement of such buoyed mineral and metallic particles along upon and over the surface of the liquid C at a rate in excess of the rate of movement

of the liquid C is obtained, thereby producing a frictional movement facilitating the separation of such buoyed mineral and metallic particles from the gangue of the ore-stock, whereby the capacity of the separator is increased.

Having thus described our invention, what we claim, and desire to secure by Letters Patent, is—

1. The herein-described process for concentrating ores, which consists in commingling with pulverized ore-stock buoyant material, then submitting the commingled pulverized ore-stock and buoyant material to movement and pressure and so joining the buoyant material to the metallic and mineral particles in the pulverized ore, and then applying the prepared ore while in a dry state to a stratifying apparatus, whereby the buoyed metallic and mineral particles are separated from the gangue by the settling of such gangue, substantially as described.

2. The herein-described process for concentrating ores, which consists in first comminging with pulverized ore-stock buoyant material, then submitting the commingled pulverized ore-stock and buoyant material to movement and pressure and so joining the buoyant material to the metallic and mineral particles in the pulverized ore, and then applying such prepared ore while in a dry state to the surface of liquid, whereby the buoyed metallic and mineral particles are floated on such liquid and separated from the gangue, which settles in the liquid, substantially as described.

3. The process, substantially as described, for concentrating ores, which consists in first joining the metallic and mineral particles in the pulverized ore with a quantity of buoyant material and then sifting or blowing the prepared ore while in a dry state upon the surface of liquid, whereby the buoyed metallic and mineral particles are made to float and thus separate from the gangue, which settles.

4. The herein-described process for concentrating ores, which consists in first joining the metallic and mineral particles in the pulverized ore with a quantity of buoyant material, then sifting or blowing the prepared ore while in a dry state upon the surface of liquid, and then in obtaining a current of air over the liquid, whereby the buoyed metallic and mineral particles are made to float and to move along on and over the surface of such liquid, and thus separate from the gangue, which settles.

5. The herein-described process for concentrating ores, which consists in first joining the metallic and mineral particles in the pulverized ore with a quantity of buoyant material, of obtaining a body of liquid having an effervescent condition, and then sifting or blowing the prepared ore while in a dry state upon the surface of liquid in such effervescing condition, whereby the buoyed metallic and mineral particles are made to float on the surface of such liquid, and thus separate from the gangue, which settles.

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6 The herein-described process for concentrating ores, which consists in first joining the metallic and mineral particles in the pulverized ore with a quantity of buoyant material, of obtaining a body of liquid having an effervescent condition, then sifting or blowing the prepared ore while in a dry state upon the surface of

liquid in such effervescing condition, and then in obtaining a current or air over the liquid, whereby the buoyed metallic and mineral particles are made to float and to move along on and over *on* the surface of such liquid, and thus separate from the gangue, which settles.

CHARLES B. HEBRON.
CARRIE J. EVERSON.

Witnesses to signature of Charles B. Hebron:
CHARLES T. BROWN.
J. L. EVERSON.

Witnesses to signature of Carrie J. Everson:
E. A. FAY.
B. CURTIS.

No. 653,340. Patented July 10, 1900.

F. E. ELMORE.

APPARATUS FOR SEPARATING METALLIC FROM ROCKY CONSTITUENTS OF ORES.

(Application filed Sept. 26, 1899.)

(No Model.) 2 Sheets—Sheet 1.

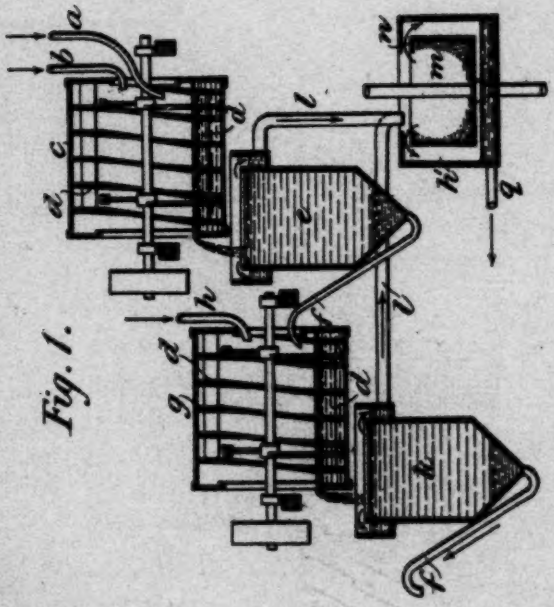

Fig. 1.

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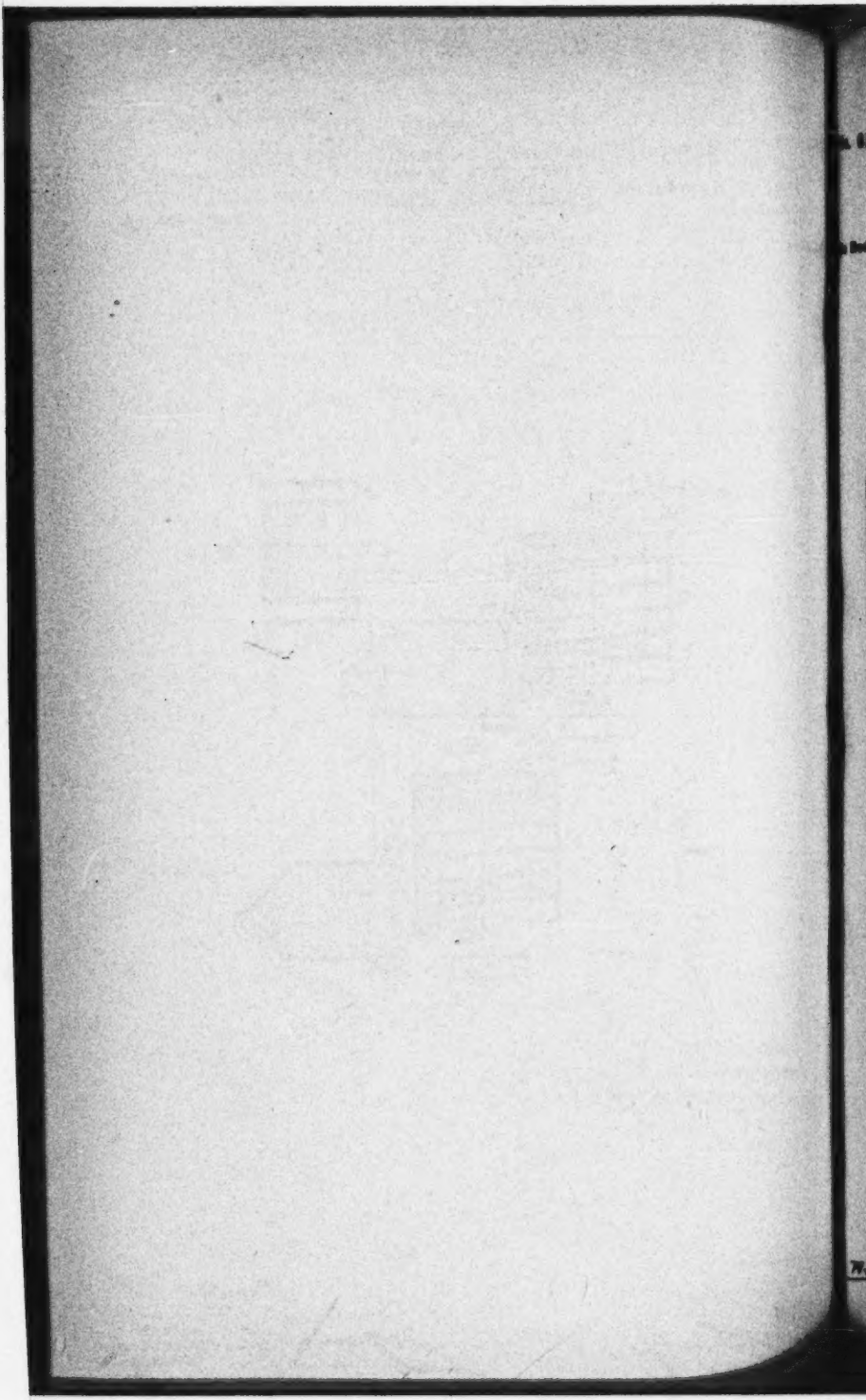
Witnesses
[illegible]

Inventor
Frank E. Elmore
by James L. Norris



No. 653,340 Patented July 10, 1900.

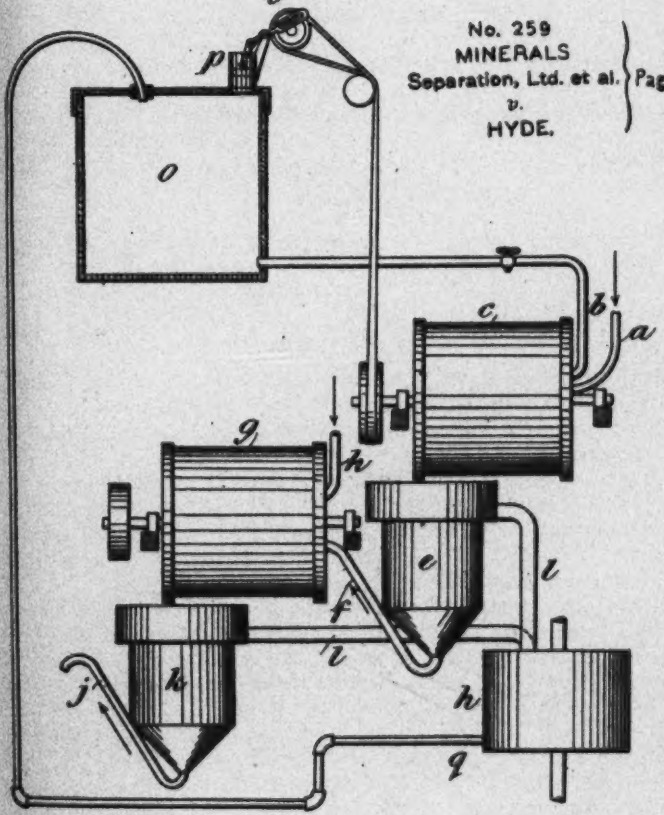
F. E. ELMORE.

APPARATUS FOR SEPARATING METALLIC FROM ROCKY CONSTITUENTS OF ORES.

(Application filed Sept. 25, 1899.)

(No Model.) 2 Sheets—Sheet 2.

Fig. 2.



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Witnesses
W. B. Taylor
Humbert

Inventor
Francis E. Elmore
By James L. Norris

1129 [DEFENDANT'S EXHIBIT—DRAWINGS AND SPECIFICATION OF LETTERS PATENT NO. 653,340, PATENTED JULY 10, 1900, ISSUED TO F. E. ELMORE.]

(Here follow diagrams marked pp. 1130 and 1131.)

1132 United States Patent Office.

FRANCIS EDWARD ELMORE, of Leeds, England.

Apparatus for Separating Metallic from Rocky Constituents of Ores.

Specification Forming Part of Letters Patent No. 653,340, Dated July 10, 1900.

Original Application Filed April 10, 1899, Serial No. 712,454. Divided and This Application Filed September 23, 1899. Serial No. 731,464. (No Model.)

To all whom it may concern:

Be it known that I, Francis Edward Elmore, a citizen of England, residing at Pontefract road, Hunslet, Leeds, in the county of York, England, have invented certain new and useful Improvements in Apparatus for Separating Metallic from Rocky Constituents of Ores, (for which I have applied for a patent in Great Britain, dated October 18, 1898, No. 21,948,) of which the following is a specification.

This invention, which was originally comprised in the application for patent filed April 10, 1899, Serial No. 712,454, but has been divided out at the request of the Office, relates to apparatus for separating the metallic from the rocky constituents of ores, which I effect by bringing a mixture of the pulverized ore with water into contact with more or less thick oil, which entraps the metallic constituents and allows the rocky constituents to pass away with the water. I then separate the metallic particles from the oil, which can be used for repeated operations. The thick oil which I employ is the thick tarry residue, usually called "residuum," of mineral oil after some of the more volatile constituents have been distilled off. When the whole of the one has been mixed with water in quantity amounting to several times the weight of the ore, this is then mixed with the thick oil. The metallic portions of the ore are retained in the oil, which does not even adhere to the earthy ingredients, the latter being held in suspension in the water.

In the accompanying drawings, Figure 1 is a vertical sectional view of an apparatus suitable for carrying my invention into effect,

omitting the elevated cistern; and Fig. 2 is a side elevation of the apparatus, showing the elevated cistern.

In order to enable those skilled in the art to practice my invention, I will now describe the same in detail with reference to the drawings.

The mixture of pulverized ore and water supplied by pipe *a* and also the oil supplied by pie *b* flow into one end of a drum *c*, which slowly revolves on a horizontal axis. At each end of the dum there is a circular opening, and within the drum annular helical ribs *d* extend from end to end, the spaces between these ribs being divided into cells by a number of equidistant blades. The ore and water and the oil, which are thus mingled without being broken up, so as to form a uniform mixture, are carried from the end of the drum where they entered to the opposite end, whence they are discharged into a water-subsiding vessel *e*, in which the water and rocky constituents mostly subside, while the oil, with the metallic constituents, floats above. The lowest layer is drawn away as tailings, which may be again treated with oil by leading them by a pipe *f* to a second drum *g*, where they are again mixed with oil supplied by a pipe *h*, the mixture being discharged into a second subsidence vessel *k*. This may be again repeated until little or none of the metallic constituents remain in the tailings. The upper layer from the subsidence vessels is led by pipes *l* into a centrifugal drum *m*, containing a little water. As the drum rapidly revolves the metallic particles are caused by centrifugal force to pass from the oil to the water, which forms a layer next the circumference of the drum, the side of which is closed, while the oil, being lighter, flows over an inwardly-projecting lip *n* into the casing *h'* of the drum, whence it is removed by a pipe *q* to be used over again. When the layer of particles and water in the centrifugal drum attains a certain thickness, the drum is stopped, the layer is removed, and the drum receives a fresh charge of water and is again worked.

The oil may be pumped up through pipe *q* to an elevated cistern *o* to supply the drums *c* and *g;* but in order to clear the oil from air-bubbles I prefer to draw the oil up to the cistern by creating a partial vacuum in the cistern through the medium of any suitable means, such as a vacuum-pump *p*.

In carrying out my invention I do not employ an oil mixture. The thick oil of the kind before set forth, with the metallic ingredients entrapped in it, floats over the water, which holds in suspension the earthy ingredients which have no oil whatever adhering to them.

Instead of employing centrifugal force to separate the oil from the metallic matters mixed with it the mixture may be thinned by heating it or mingling it with solvents of the oil, such as benzoline, and left for subsidence or subjected to filter-pressing, so that the greatest portion of the oil can be recovered for subsequent use.

1133 & 1134

Having thus described the nature of this invention and the best means I know of carrying the same into practical effect, I claim—

1. The combination in an apparatus for separating metallic from rocky constituents of ore, of a rotary drum having internal helical

ribs, pipes for delivering oil and ore and water into one end of said drum, a water-subsiding vessel arranged below the drum and receiving the oil, ore and water therefrom, a centrifugal drum arranged below said water-subsiding vessel, and a pipe for conducting the metallic portions and the oil from the top of the water-subsiding vessel into said centrifugal drum, substantially as described.

2. The combination in an apparatus for separating metallic from rocky constituents of ore, of a rotary drum having internal helical ribs divided into cells by longitudinal blades, pipes for delivering oil and ore and water into one end of said drum, a water-subsiding vessel arranged below the drum and receiving the oil, ore and water therefrom, a centrifugal drum arranged below the water-subsiding vessel and constructed with an inwardly-projecting lip and a surrounding casing, and a pipe for conducting the metallic portions and oil from the top portion of the water-subsiding vessel into said centrifugal drum at a point in proximity to the inwardly-projecting lip thereof, substantially as described.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

FRANCIS EDWARD ELMORE.

Witnesses:
FRANCIS W. FRIGOUT.
A. NUTTING.

1135 [DEFENDANT'S EXHIBIT DRAWING AND SPECIFICATION OF LETTERS PATENT NO. 676,679, PATENTED JUNE 18, 1901, ISSUED TO FRANCIS EDWARD ELMORE.]

(Here follow diagrams marked pp. 1136 and 1137.)

1138 United States Patent Office.

FRANCIS EDWARD ELMORE, of Leeds, England.

Process of Separating Metallic from Rocky Constituents of Ores.

Specification Forming Part of Letters Patent No. 676,679, Dated June 18, 1901.

Application Filed April 10, 1899. Serial No. 712,454. (No Specimens.)

To all whom it may concern:

Be it known that I, Francis Edward Elmore, electrometallurgist, a citizen of England, residing at Pontefract road, Hunslet, Leeds, in the county of York, England, have invented certain new and useful Improvements in Processes of Separating Metallic from Rocky Constituents of Ores, (for which I have applied for a patent in Great Britain, dated October 18, 1898, No. 21,948,) of which the following is a specification.

My invention relates to a method of separating metallic constituents of ore from rocky and other impurities, which is distinguished from the usual amalgamation processes in which the ore forms an amalgam with mercury.

It consists in mixing the crushed ore with water and mixing with the ore and water a substance other than mercury which has the power of causing the metallic portions of the ore only to adhere to it, while the water and rock or other impurities of the ore remain unaffected and may be drawn off. The metallic constituents of the ore are then recovered from the substance in which they are entrapped. I have found that the heavier oils are efficacious for this purpose and particularly that kind of oil known as the "residuum" of mineral oil after the more volatile elements have been distilled off.

In carrying out my process I prefer to mix the ore with water—as, for instance, by the wet crushing method in common use—using a sufficient quantity of water to make a freely-flowing mixture, the fineness of the ore depending upon the particular kind of ore treated. I then place the ore and water in a suitable vessel, add a quantity of

No. 676,679. Patented June 18, 1901.

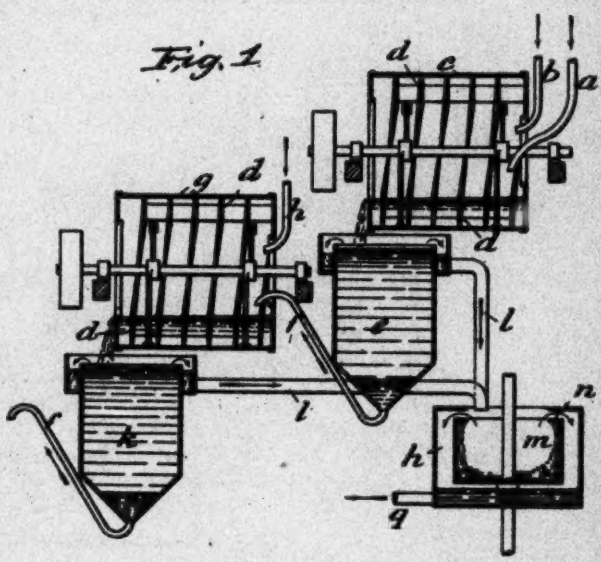
F. E. ELMORE.

PROCESS OF SEPARATING METALLIC FROM ROCKY CONSTITUENTS OF ORES.

(Application filed Apr. 10, 1899.)

(No Model.) 2 Sheets—Sheet 1.

Fig. 1.



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Witnesses
Bruce A. Elliott.

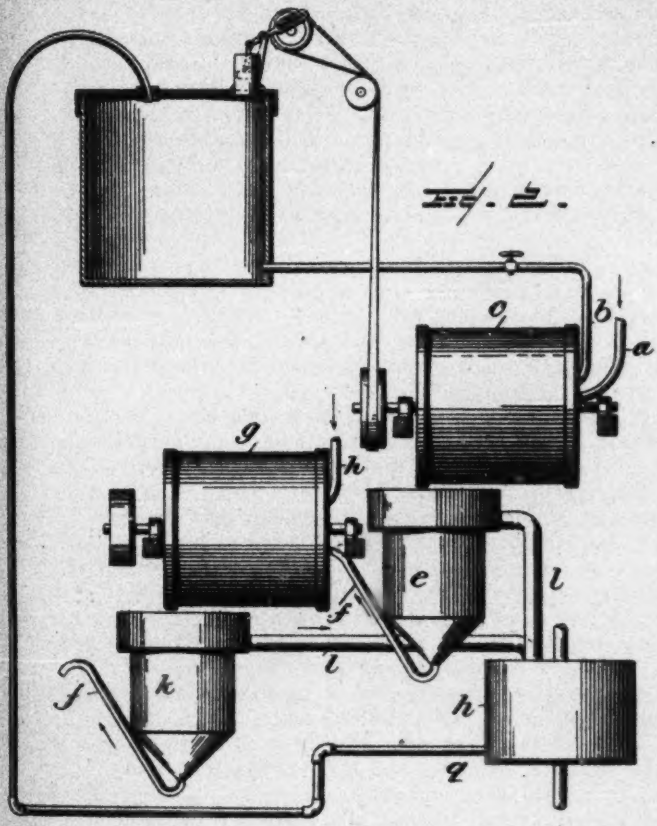
Inventor
Francis E. Elmore
By James L. Norris
Atty.

No. 676,679. Patented June 18, 1901.

F. E. ELMORE.

PROCESS OF SEPARATING METALLIC FROM ROCKY CONSTITUENTS OF ORES.

(No Model.) (Application filed Apr. 10, 1899.) 2 Sheets—Sheet 2.



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Witnesses:
L. C. Hills.

Inventor
Frances E. Elmore
By James L. Norris.
Attorney

the oil depending upon the particular kind of ore under treatment, and then agitate the mixture without breaking up the oil into small globules. The metallic particles will adhere to the oil and be buoyed up and floated by it, while the other constituents of the ore will remain in the water. The water and attendant impurities are then drawn off, leaving the oil and metallic particles. The metallic particles are easily separated from the oil by mechanical or other means.

In the accompanying drawings, Figure 1 is a vertical sectional view of an apparatus suitable for carrying my invention into practice, omitting the elevated cistern; and Fig. 2 is a side elevation of the apparatus, showing the elevated cistern.

In order to enable those skilled in the art to practice my invention, I will now describe the same in detail, with reference to the drawings.

The mixture of pulverized ore and water supplied by pipe *a* and also the oil supplied by pipe *b* flow into one end of a drum *c*, which slowly revolves on a horizontal axis. At each end of the drum there is a circular opening, and within the drum annular helical ribs *d* extend from end to end, the spaces between these ribs being divided into cells by a number of equidistant blades. The ore and water and the oil, which are thus mingled without being broken up so as to form a uniform mixture, are carried from the end of the drum where they entered to the opposite end, whence they are discharged into a vessel *e*, in which the water and rocky constituents mostly subside, while the oil, with the metallic constituents, floats above. The lowest layer is drawn away as tailings, which may be again treated with oil by leading them by a pipe *f* to a second drum *g*, where they are again mixed with oil supplied by a pipe *h*, the mixture being discharged into a second subsidence vessel *k*. This may be again repeated until little or none of the metallic constituents remain in the tailings. The upper layer from the subsidence vessels is led by pipes *l* into a centrifugal drum *m*, containing a little water. As the drum rapidly revolves the metallic particles are caused by centrifugal force to pass from the oil to the water, which forms a layer next the circumference of the drum, the side of which is closed, while the oil, being lighter, flows over an inwardly-projecting lip *n* into the casing *h'* of the drum, whence it is removed by a pipe *q* to be used over again. When the layer of particles and water in the centrifugal drum attains a certain thickness, the drum is stopped, the layer is removed, and the drum receives a fresh charge of water and is again worked.

The oil may be pumped up through pipe *q* to an elevated cistern *o* to supply the drums *c* and *g*; but in order to clear
1139 & 1140 the oil from air-bubbles I prefer to draw the oil up to the cistern by creating a partial vacuum in the cistern through the medium of any suitable means, such as the vacuum-pump *p'*.

In carrying out my invention I do not employ an oil mixture. The thick oil of the kind before set forth, with the metallic ingredients entrapped in it, floats over the water, which holds in suspen-

sion the earthy ingredients which have no oil whatever adhering to them.

Instead of employing centrifugal force to separate the oil from the metallic matters mixed with it the mixtutre may be thinned by heating it or mingling it with solvents of the oil, such as benzolin, and left for subsidence or subjected to filter-pressing, so that the greatest portion of the oil can be recovered for subsequent use.

Having thus described the nature of this invention and the best means I know of carrying the same into practical effect, I claim—

1. The process of separating the metallic from other constituents of ore, which consists in mixing with crushed ore to which sufficient water has been added to make a flowing mixture a substance other than mercury to which the metallic particles only will adhere, and then recovering the metallic particles from such substance, substantially as described.

2. The process of separating the metallic constituents of ore from the rocky or other impurities, which consists in mixing crushed ore with a sufficient quantity of water to make a flowing mixture, mixing with the ore and water a quantity of oil, and recovering the metallic particles from the oil, substantially as described.

3. A process of separating the metallic from the other constituents of ore, which consists in mixing crushed ore and water to form a flowing mixtutre, mixing with the ore and water a substance other than mercury to which the metallic particles only will adhere, separating the water and impurities from the substance containing the metal, and recovering the metal from such substance, substantially as described.

4. The method of separating the metallic from other constituents of ore which consists of commingling pulverized ore to which sufficient water has been added to make a flowing mixture with oil, separating the oil and metallic constituents contained therein from the water and impurities, and separating the metallic constituents from the oil, substantially as described.

5. A process for separating metallic from rocky constituents of ore by mixing the pulverized ore with water and mixing the ore and water with oil, allowing the water carrying rocky materials to subside, while the oil carrying metallic constituents floats above, and separating the oil from these constituents substantially as described.

6. The improved process for separating metallic from rocky constituents of ore which consists in mixing the pulverized ore with water, flowing the same into contact and admixture with flowing oil, subjecting the mixture of ore, water and oil to subsidence, and then separating the oil from the rocky constituents and water, substantially as described.

7. The herein-described process for separating the metallic from the rocky constituents of ore, which consists in first mixing pulverized ore with a large quantity of water to maintain the mixture in a freely-flowing condition, then adding to this mixture of water and ore a thick oil of the character set forth, which oil will adhere to the metallic constituents but not to the wet rocky constituents, then subsiding the water and rocky material and causing the oil carrying the

metallic constituents to float off over the body of water and finally separating said oil from said metallic constituents, substantially as specified.

8. The herein-described process for separating the metallic from the rocky constituents of ore, which consists in first mixing pulverized ore with a large quantity of water to maintain the mixture in a freely-flowing condition, then adding to this mixture of water and ore a thick oil of the character set forth, which oil will adhere to the metallic constituents but not to the wet rocky constituents, then subsiding the water and rocky material and causing the oil carrying the metallic constituents to float off over the body of water and finally separating said oil from said metallic constituents by centrifugal action, substantially as specified.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

FRANCIS EDWARD ELMORE.

Witnesses:
THOMAS BROWN.
THOBIAS HENRY BUTT.

1141 [DEFENDANT'S EXHIBIT DRAWING AND SPECIFICATION OF LETTERS PATENT No. 689,070, PATENTED DECEMBER 17, 1901, ISSUED TO A. S. ELMORE.]

(Here follows diagram marked p. 1142.)

1143 United States Patent Office.

ALEXANDER STANLEY ELMORE, of London, England.

Separating Mineral Substances by the Selective Action of Oil.

Specification Forming Part of Letters Patent No. 689,070, Dated December 17, 1901.

Application Filed April 13, 1901. Serial No. 55,776. (No Specimens.)

To all whom it may concern:

Be it known that I, Alexander Stanley Elmore, a citizen of England, residing at 4 Bishopsgate street Within, London, England, have invented a certain new and useful Improvement in Separating Mineral Substances by the Selective Action of Oil, (for which I have applied for a patent in Great Britain, dated March 28, 1901, No. 6,519,) of which the following is a specification.

The selective action of oil has been utilized for separating metallic substances from earthy or rocky constituents of ores. This has generally been done by pulverizing the ore and suspending it in a considerable quantity of water, so as to make a freely-flowing pulp, then mingling with it oil, preferably heavy oil, such as is obtained from petroleum after some of the lighter oils have been distilled from it. When the mixture rests, the oil, with most of the metallic substances entrapped in it, floats at the top and is separated from the rocky or earthy matters, which are run off with the water as tailings. The oil is afterward separated from the metallic substances, usually by centrifugal action. In carrying on this separating process I have discovered that in some cases a slight acidulation of the mixture greatly enhances the selective action of the oil, so that metallic substances, as well as other mineral substances, such as sulfur and plumbago, can be separated from the earthy matters with which they are naturally associated better than when there is no acid present. By this means some metallic substances can be separated from others—such, for instance, as sulfids from oxids. The acidulation may be effected either by adding a little acid to the oil, in which case an acid that will dissolve in or mix readily with the oil, but which is insoluble

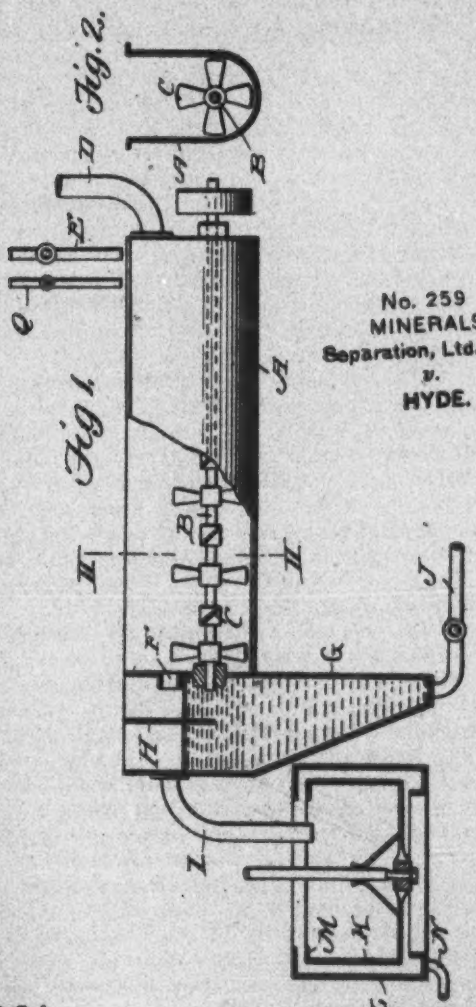
No. 683,870. Patented Dec. 17, 1901. 1142

A. S. ELMORE.

SEPARATING MINERAL SUBSTANCES BY THE SELECTIVE ACTION OF OIL.

(Application filed Apr. 18, 1901.)

(No Model.)



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v.
HYDE.

Witnesses:
[illegible]

Inventor
Alexander S. Elmore
By James L. Norris.
Atty.

or nearly so, in water—as, for instance, oleic acid—is to be preferred, or the acid may be added to the aqueous pulp, in which case sulfuric acid may be employed or the acid cuprous liquors obtained in mine working. The quantity of acid added in either case is small, as it often need not exceed one five-hundredth part of the volume of oil or water employed in the operation. The quantity of acid required to produce the best result varies, according to the character of the material treated, and I therefore do not confine myself to any definite proportion.

An apparatus by which my process can be carried out in practice and which forms the subject of a pending application for Letters Patent filed the 8th day of August, 1901, Serial No. 71,372, is illustrated by the accompanying drawings, in which—

Figure 1 is a view partly in section and partly in elevation, and Fig. 2 a cross-sectional view.

In applying my invention to the separation of metallic and earthy or rocky ingredients of ore I prefer to mix with the powdered ore from five to ten times its weight of water, forming a thin freely-flowing pulp, which I allow to flow into the mixer A through a pipe D. Into this mixer I also admit a thin stream of oil from a pipe E, provided with a regulating-valve, and a small quantity of acid from a pipe Q, also provided with a regulating-valve. The oil and acid are mixed with the pulp by the rotating beater C. The oil by its selective action coats or absorbs the metallic particles, sulfids, the tellurids, and the like. If plumbago, elementary sulfur, or other substances of like character are present, the oil attaches itself to or coats such particles, while it does not coat or attach itself to the rocky or earthy particles present. The liquid mineral pulp, oil, and acid are caused to travel along the mixer A and become thoroughly mixed. This mixture issues by an opening F into a subsidence-tank G, which has in its upper part a partition H, extending down a little below the level of an outlet-pipe I. In the tank G a separation takes place of the metallic from the rocky or earthy ingredients of the mixture, the metalic ingredients adhering to the oil and by it floated to the top on the left side of the partition H, while the earthy and rocky ingredients subside and are allowed to issue through a pipe J, provided with a regulating-cock. The metallic ingredients, with the oil and acid, are discharged by the pipe I into the drum K of a centrifugal machine which revolves rapidly in a casing L. The drum has an inwardly-projecting flange M at its upper edge. As the drum revolves the metallic matters, owing to their density, accumulate in an annular layer at the circumference of the drum, while the oil and acid collect inside and flow over the flange M into the casing L, whence they are conducted away through a pipe N. From time to time the revolution of the drum is stopped and the metallic matter removed.

1144

Having thus described the nature of this invention and the best means I know of carrying the same into practical effect, I claim—

The process for separating metallic and rocky constituents of ore which consists in mixing pulverized ore with water and mixing the ore and water with oil in the presence of an acid, allowing the

mixture to rest whereby the oil having the metallic substances entrapped in it floats at the top of the mixture, and separating the metallic constituents from the oil, substantially as described.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

ALEXANDER STANLEY ELMORE.

Witnesses:
GERALD L. SMITH.
W. M. HARRIS.

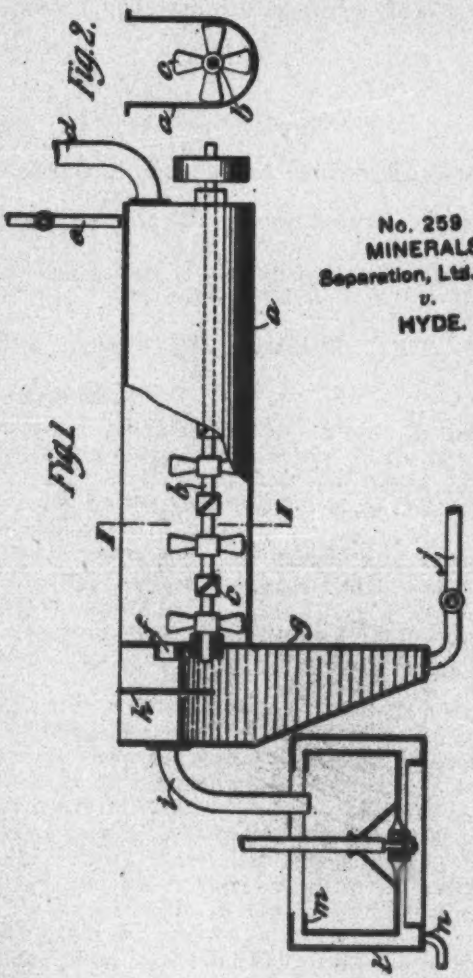
No. 692,643. Patented Feb. 4, 1902.

A. S. ELMORE.

APPARATUS FOR SEPARATING MINERALS BY SELECTIVE ACTION OF OILS.

(Application filed Aug. 6, 1901.)

(No Model.)



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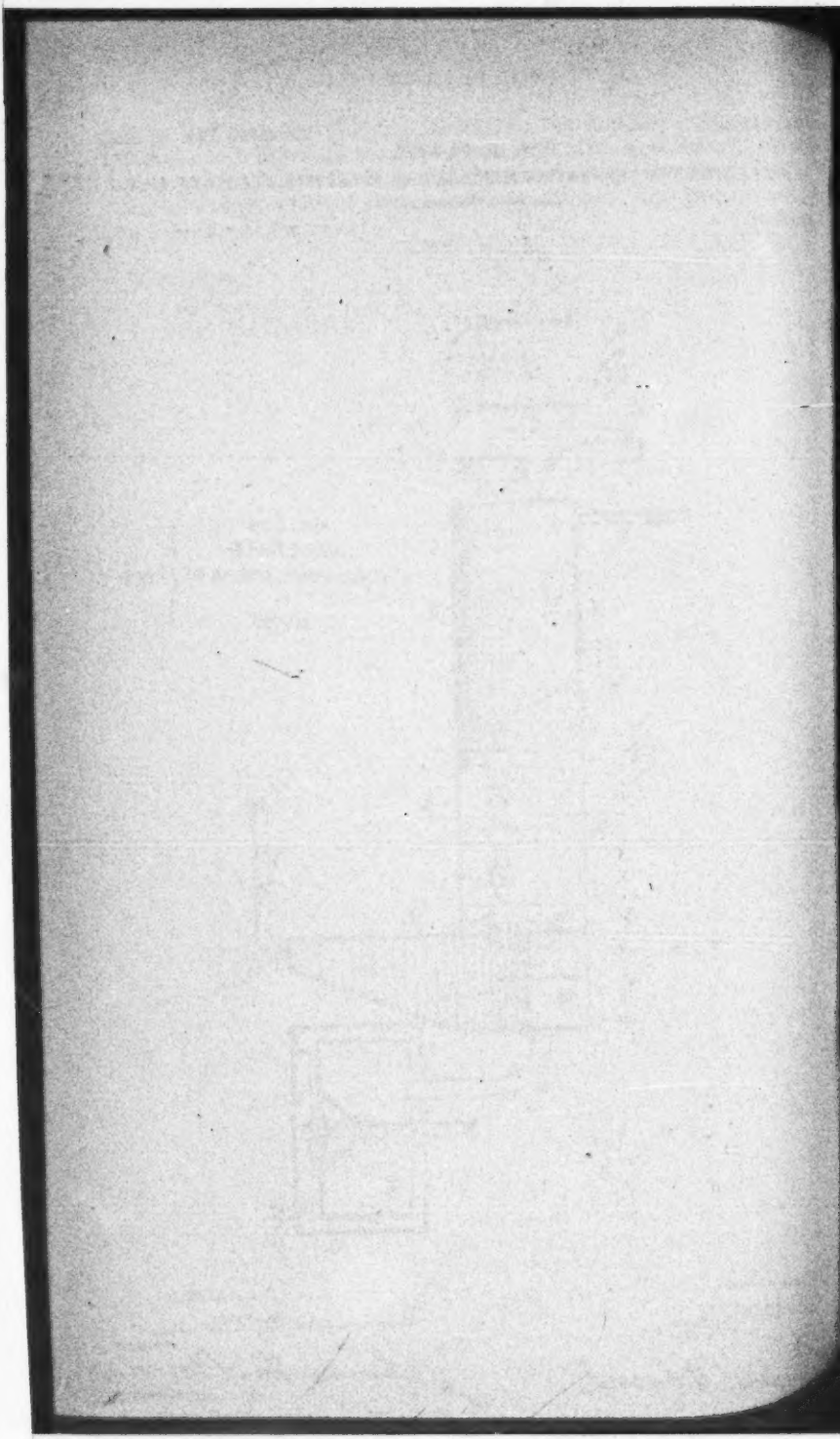
Witnesses
Edward Thume.

Inventor
Albert S. Elmore
by James L. Norris.
Atty.



1145 [DEFENDANT'S EXHIBIT DRAWING AND SPECIFICATION OF LETTERS PATENT NO. 692,643, PATENTED FEBRUARY 4, 1902, ISSUED TO A. S. ELMORE.

(Here follows diagram marked p. 1146.)

1147 & 1148 United States Patent Office.

ALEXANDER S. ELMORE, of London, England.

Apparatus for Separating Minerals by Selective Action of Oils.

Specification Forming Part of Letters Patent No. 692,643, Dated February 4, 1902.

Application Filed August 8, 1901. Serial No. 71,372. (No Model.)

To all whom it may concern:

Be it known that I, Alexander Stanley Elmore, a citizen of England, residing at 4 Bishopsgate street within, in the city of London, England, have invented a certain new and useful Apparatus for Separating Minerals by the Selective Action of Oils, of which the following is a specification.

This invention relates to apparatus for effecting the separation of minerals by the selective action of oils, as I shall describe, referring to the accompanying drawings.

Figure 1 is an elevation, partly sectional, of apparatus according to my invention. Fig. 2 is a transverse section on the line II II of Fig. 1.

a is a trough having a rounded bottom, in which a shaft *b*, carrying a number of inclined agitating-blades *c*, is caused to revolve by any suitable power. Into one end of the trough leads a pipe *d*, by which pulverized ore or mineral mixed with five to ten times its volume of water is fed into the trough, while oil is fed by a pipe *e* in quantity regulated by a cock. As the liquid mineral pulp and oil are caused by the blades *c* to travel along the trough *a* they become thoroughly mixed, and the mixture issues by an opening *f* into a subsidence-tank *g*, which has in its upper part a partition *h*, extending down a little below the level of an outlet-pipe *i*. In the tank *g* a separation takes place of the metallic from the rocky or earthy ingredients of the mixture, the metallic ingredients adhering to the oil and by it floated to the top on the left side of the partition *h*, while the earthy and rocky ingredients subside and are allowed to issue by a pipe *j*, provided with a regulating-cock. The metallic ingredients, with the oil, are discharged by the pipe *i* into the drum

k of a centrifugal machine, which revolves rapidly in a casing *l*. The drum *k* has an inwardly-projecting flange *m* at its upper edge. As the drum revolves the metallic matters, owing to their density accumulate in an annular layer at the circumference of the drum, while the oil collects inside them and overflows over the flange *m* into the casing *l*, whence it flows by a pipe *n*. From time to time the revolution of the drum is stopped and the metallic matter is removed from it.

Having thus described the nature of this invention and the best means I know of carrying the same into practical effect, I claim—

The combination in an apparatus for separating metallic from rocky constituents of ore, of a trough, a shaft adapted to revolve within said trough and provided with inclined blades, pipes for delivering oil and water to said trough, a subsidence-tank arranged at one end of said trough, extending below the same and communicating therewith, said tank adapted to receive the liquid mineral pulp and oil from said trough, a vertically-extending partition arranged in said tank at the top thereof for the purpose set forth, a centrifugal drum arranged at one side of said tank, a pipe connected to said tank and communicating with said drum for discharging therein the metallic ingredients and the oil, and a pipe connected to the tank for discharging therefrom the earthy and rocky ingredients.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

A. S. ELMORE.

Witnesses:
WALTER JAMES SKERTEN.
GERALD L. SMITH.

No. 729,805. PATENTED JUNE 2, 1903.

J. & L. STOVEKEN.

APPARATUS FOR EXTRACTING METALS FROM ORES.

APPLICATION FILED AUG. 12, 1902.

NO MODEL. 5 SHEETS—SHEET 1.

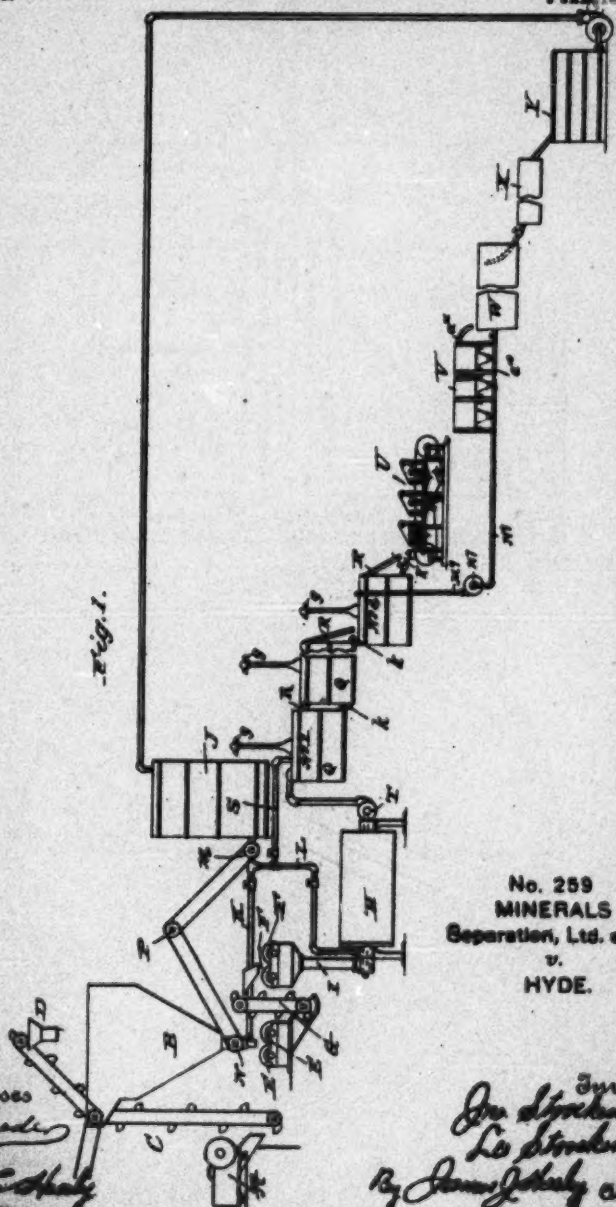


Fig. 1.

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Page 11

Witnesses
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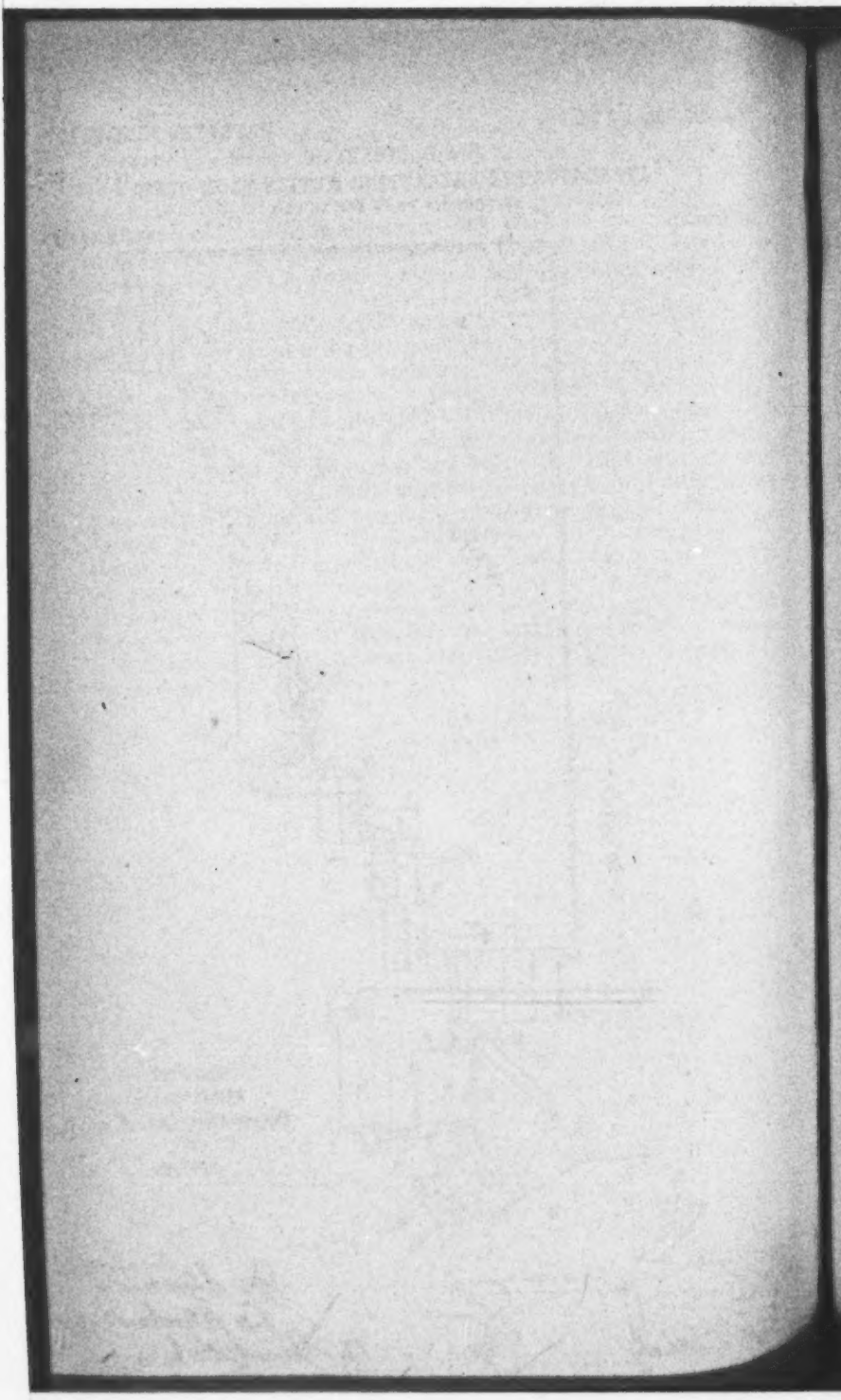
Leo Stoveken
By James J. Shealy Attorney



No. 729,805. PATENTED JUNE 2, 1903.

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J. & L. STOVEKEN.

APPARATUS FOR EXTRACTING METALS FROM ORES.

APPLICATION FILED AUG. 12, 1902.

NO MODEL. 6 SHEETS—SHEET 2.

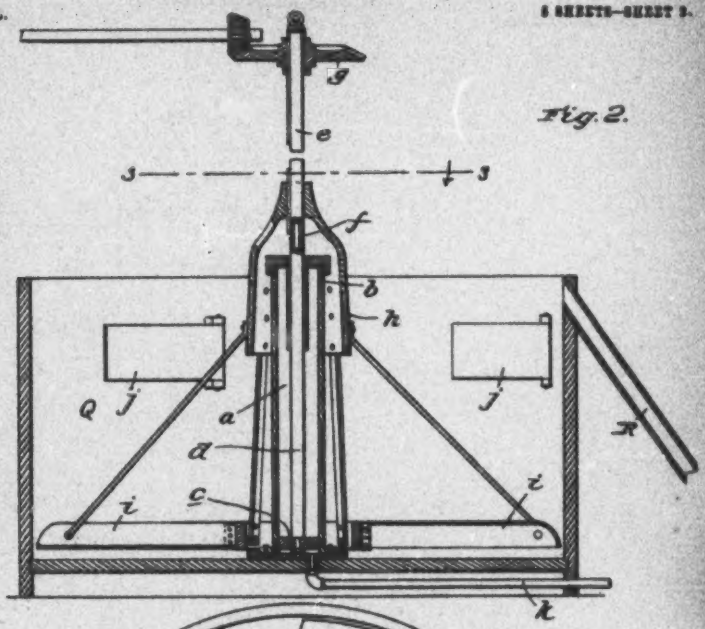

Fig. 2.

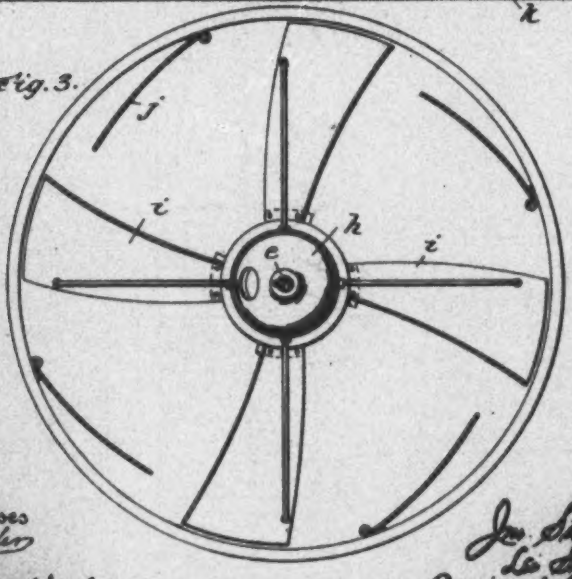

Fig. 3.

No. 259
MINERALS
Separation, Ltd. et al.
v.
HYDE.
Page 1157

Witnesses
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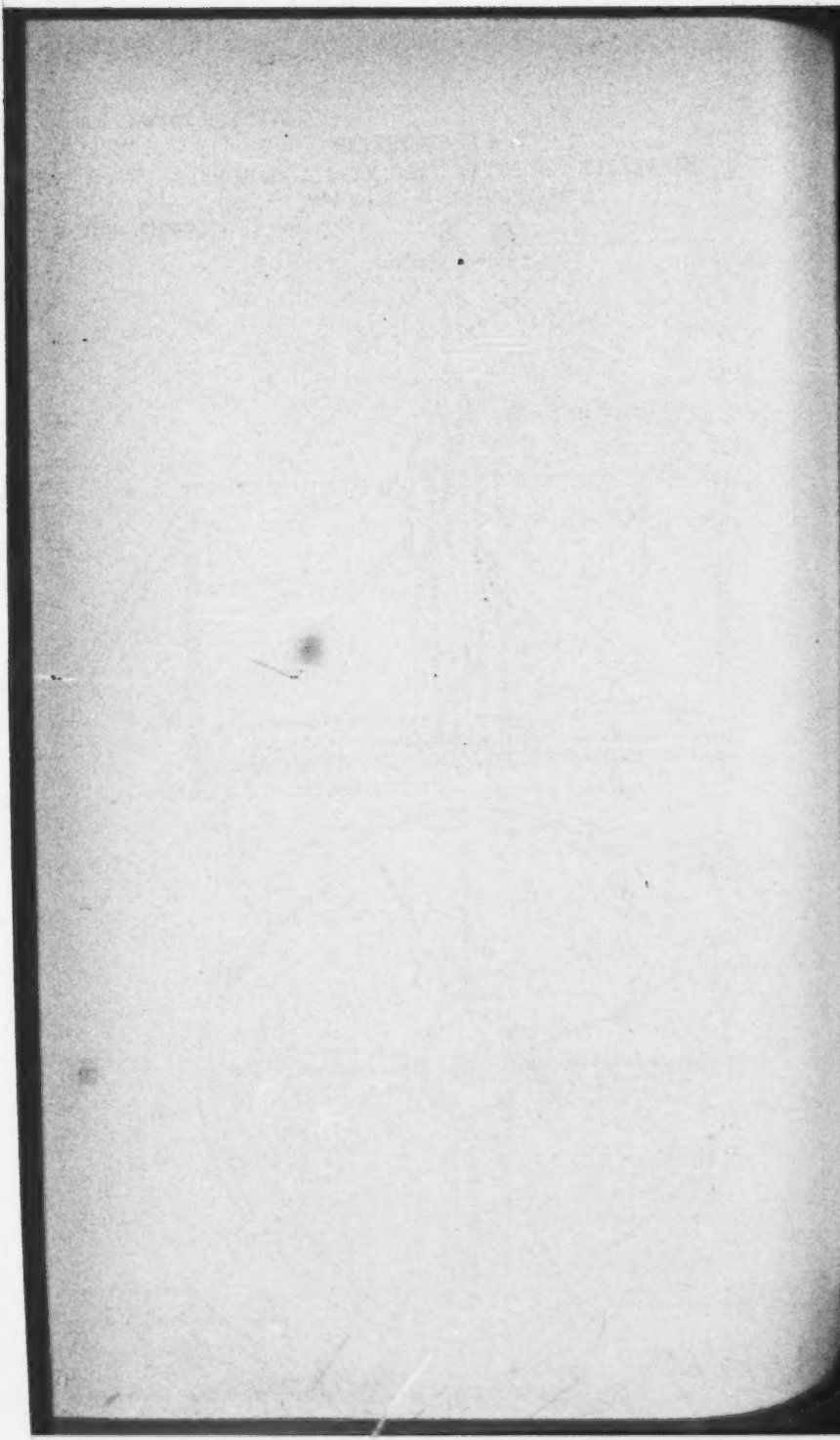

No. 729,805. PATENTED JUNE 2, 1903.

J. & L. STOVEKEN.

APPARATUS FOR EXTRACTING METALS FROM ORES.

APPLICATION FILED AUG. 12, 1902.

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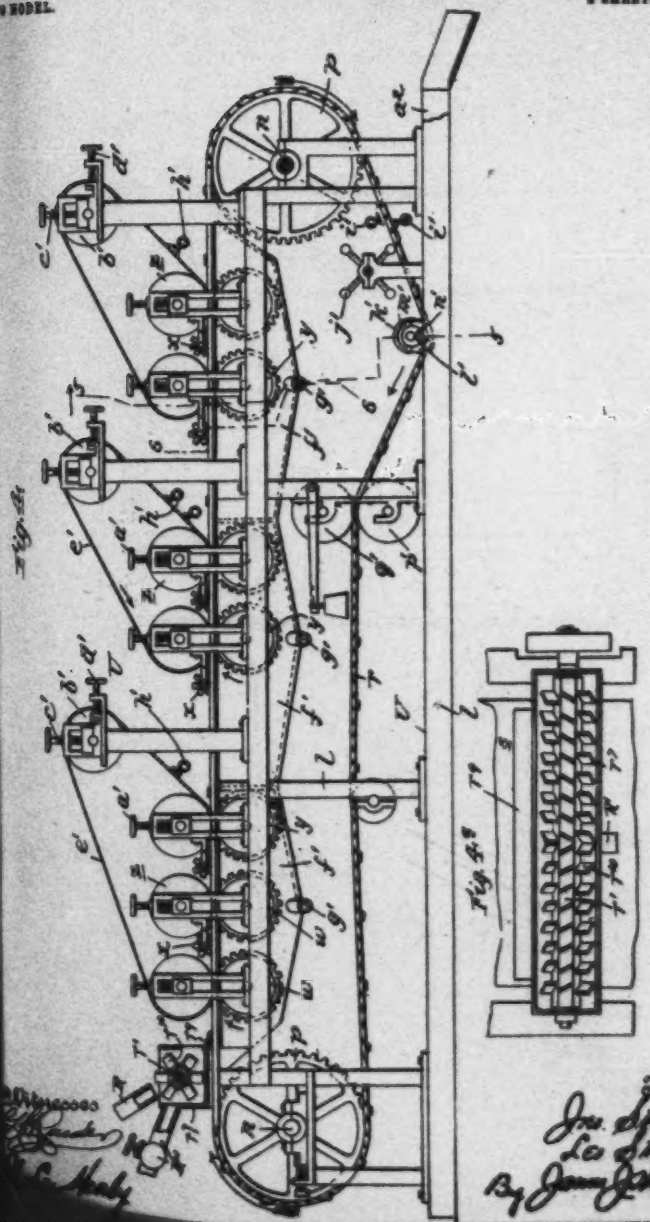

No. 259
MINERALS
Separation, Ltd. et al.
v.
HYDE.
Page 1152

Witnesses
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[illegible]

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By James J. Shelby
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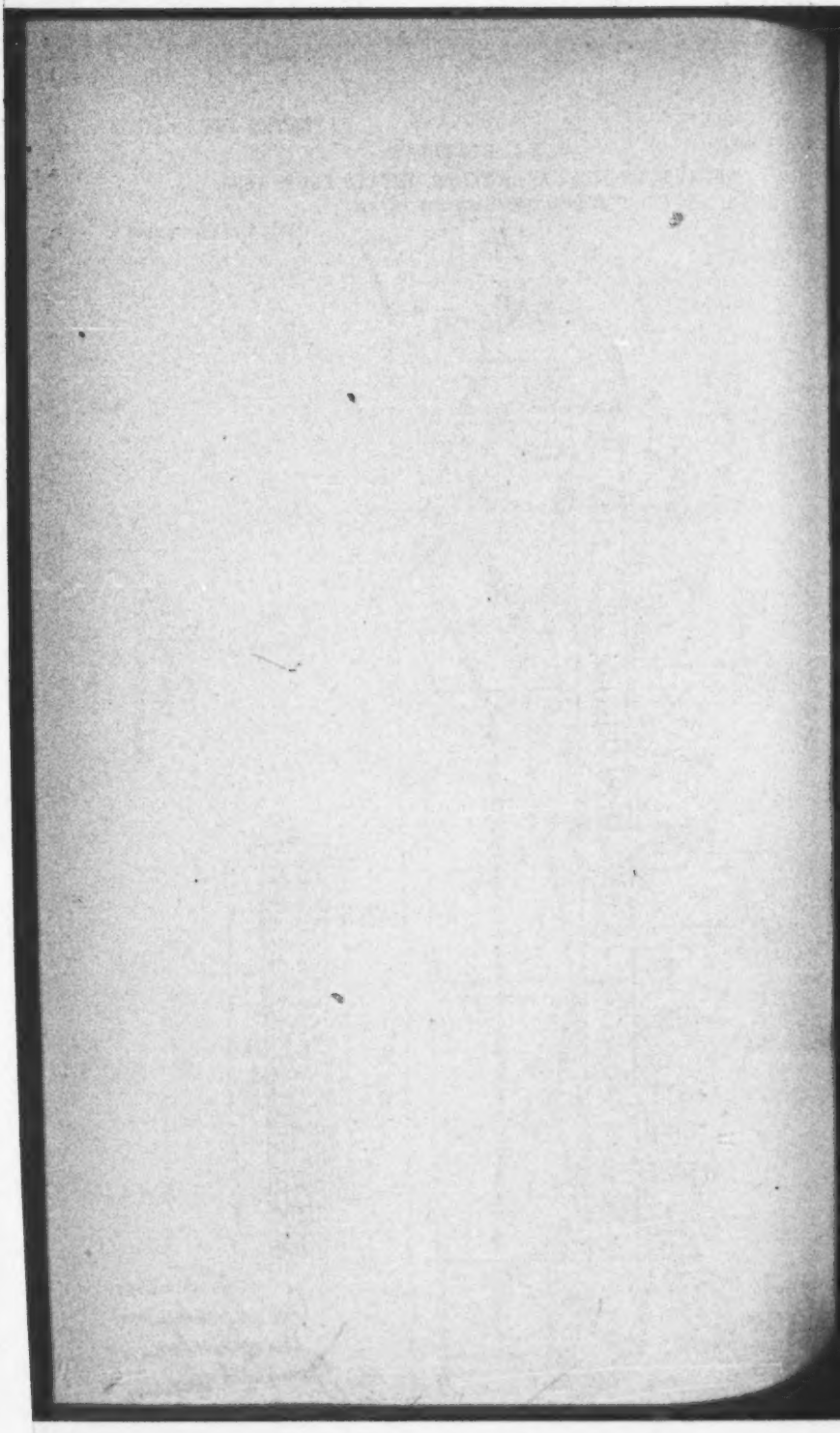

No. 729,805. PATENTED JUNE 2, 1903.

J. & L. STOVEKEN.

APPARATUS FOR EXTRACTING METALS FROM ORES.

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NO MODEL. 4 SHEETS—SHEET 4.

Fig. 5.

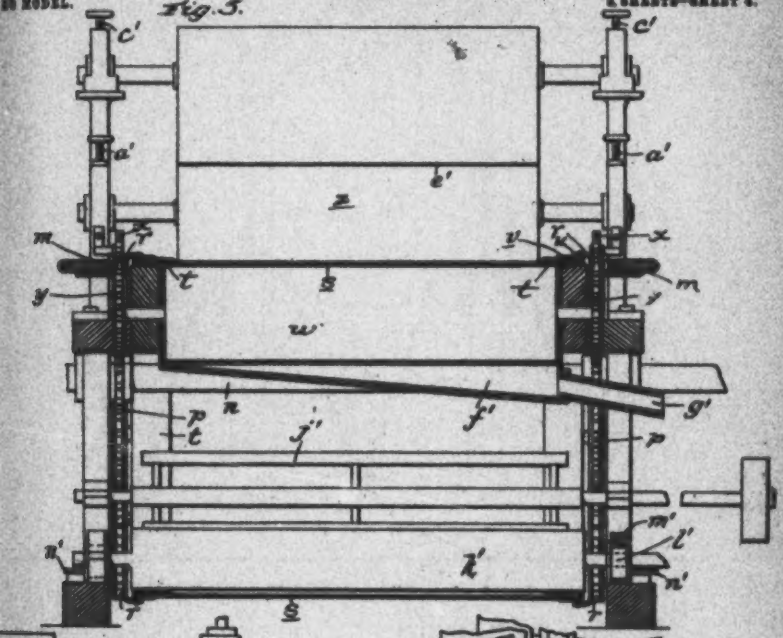


Fig. 6.

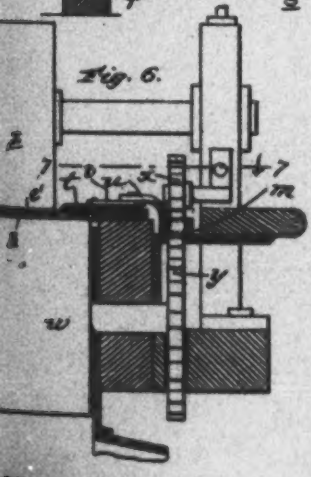
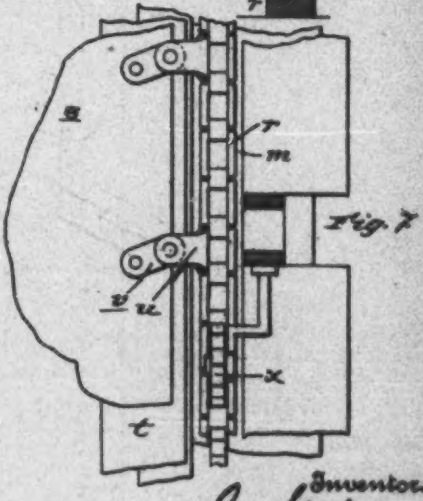
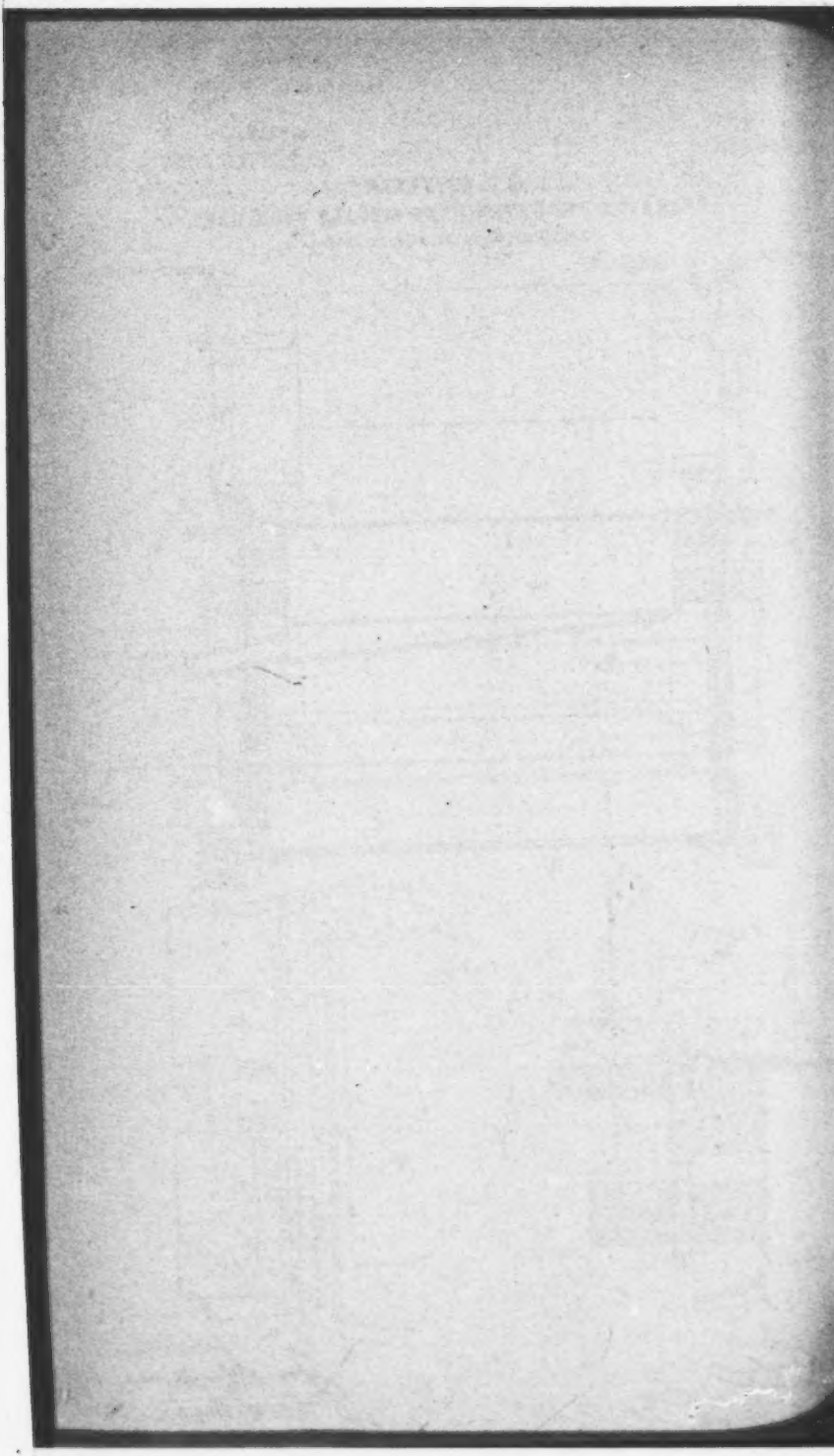


Fig. 7.



Witnesses

Inventors
Jno. Stoveken +
Les Stoveken.



No. 729,805. PATENTED JUNE 2, 1903.

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J. & L. STOVEKEN.

APPARATUS FOR EXTRACTING METALS FROM ORES.

APPLICATION FILED AUG. 12, 1902.

NO MODEL. 5 SHEETS—SHEET 5.

Fig. 8.

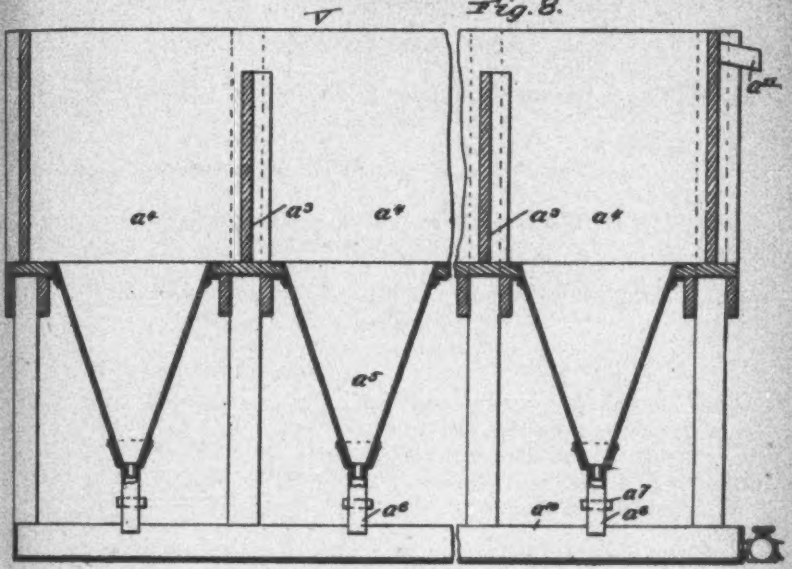
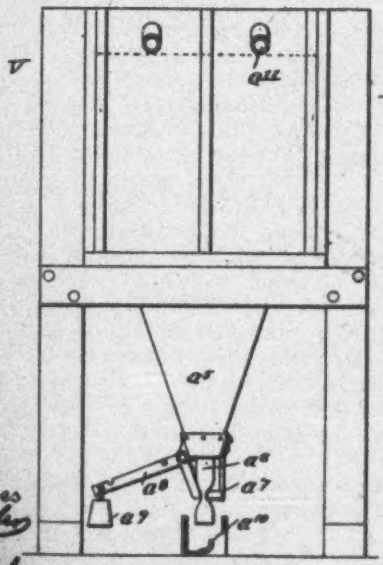


Fig. 9.



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MINERALS
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Page 115

Witnesses
[illegible]
[illegible]

Inventors
Jno. Stoveken
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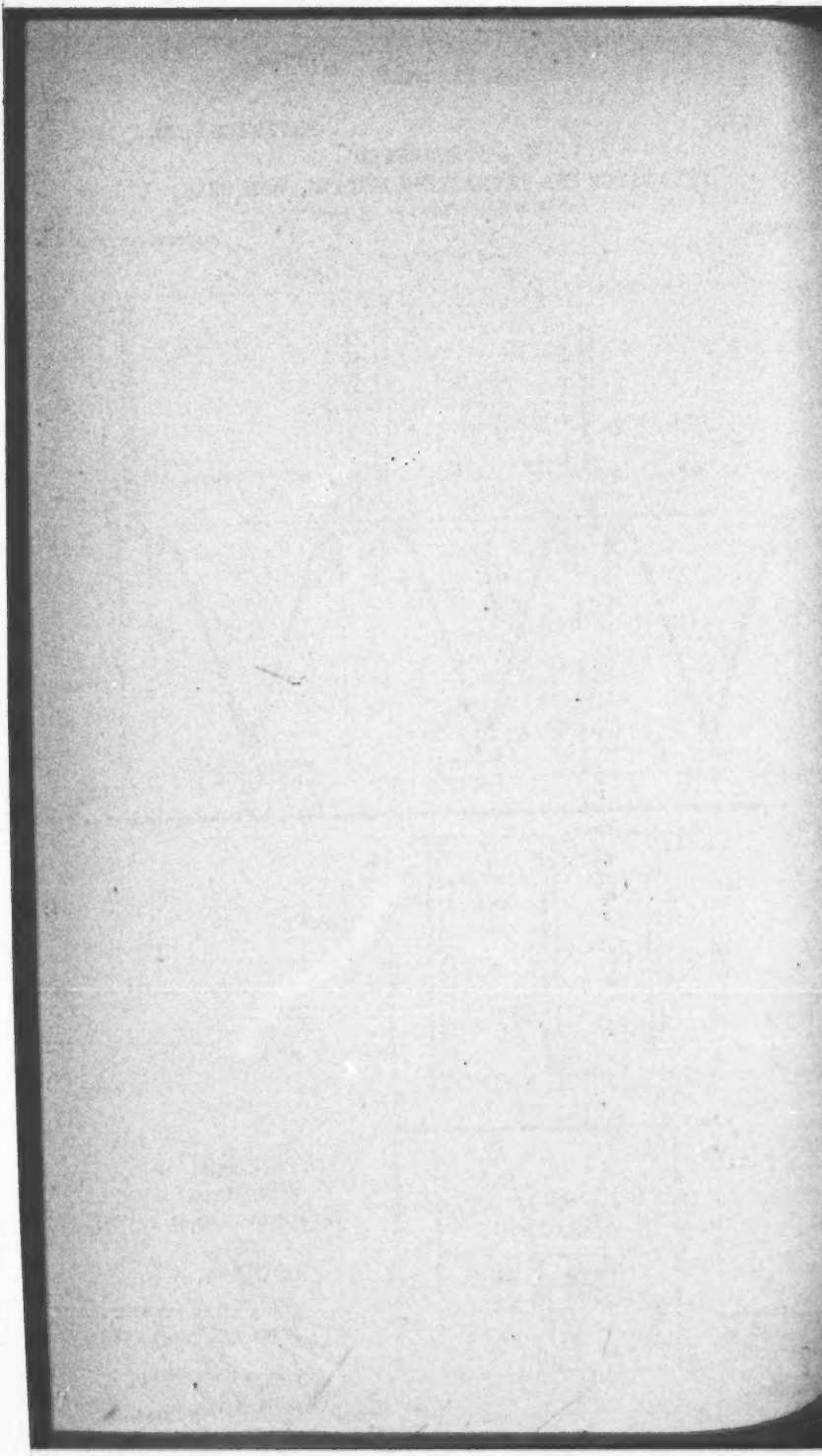
By James J. Shelby Attorney



1149 [DEFENDANT'S EXHIBIT DRAWINGS AND SPECIFICATION OF LETTERS PATENT No. 729,805, PATENTED JUNE 2, 1903, ISSUED TO J. & L. STOVEKEN.]

(Here follow diagrams marked pp. 1150 to 1154.)

1155 United States Patent Office.

JOHN STOVEKEN, of Cripple Creek, and LEO STOVEKEN, of Florence, Colorado.

Apparatus for Extracting Metals from Ores.

Specification Forming Part of Letters Patent No. 729,805, Dated June 2, 1903.

Application Filed August 12, 1902. Serial No. 119,433. (No Model.)

To all whom it may concern:

Be it known that we, John Stoveken, residing at Cripple Creek, in the county of Teller, and Leo Stoveken, residing at Florence, in the county of Fremont, State of Colorado, citizens of the United States, have invented new and useful Improvements in Apparatus for Extracting Metals from Their Ores, of which the following is a specification.

Our invention relates to apparatus for extracting precious metals from their ores; and it has for its general object to provide an apparatus designed more especially for the treatment of ores in which only a small percentage can be saved by amalgamation and which ores are of too low grade to be treated by barrel chlorination and too clayey or slimy to be percolated by cyanid solution.

The invention will be fully understood from the following description and claims when taken in conjunction with the accompanying drawings, in which—

Figure 1 is a broken side elevation of the apparatus constituting the preferred embodiment of our invention; Fig. 2, an enlarged diametrical section of one of the agitation-tanks forming part of the apparatus; Fig. 3, a section taken in the plane indicated by the broken line 3 3 of Fig. 2 looking downwardly; Fig. 4, an enlarged side elevation of the filter forming part of the apparatus; Fig. 4ª, a detailed plan view of the spreader comprised in the filter; Fig. 5, a slightly-enlarged transverse section taken on the broken line 5 5 of Fig. 4; Fig. 6, an enlarged detail section taken on the broken line 6 6 of Fig. 4; Fig. 7, a detail horizontal section taken in the plane of the broken line 7 7 of Fig. 6 looking downwardly; Fig. 8, a broken longitudinal vertical section of the decanting-vat forming part of the apparatus, and Fig. 9 an end elevation of the same with a portion of the trough broken away.

Similar letters of reference designate corresponding parts in all of the several views of the drawings, referring to which—

A, Fig. 1, is an ore-crusher, which may be of any suitable description; B, a bin for containing crushed ore; C, an elevator for transferring the crushed ore from the crusher to the bin; D, a sampler which is preferably employed, but which per se forms no part of our invention and may therefore be omitted when desired; E E, rolls disposed below the discharge of the bin B and having for their purpose to reduce the size of the pieces of ore; F F, rolls, the purpose of which is to further reduce the size of the pieces of ore; G, an endless elevator arranged to receive the ore as it comes from the rolls E and transfer it to the rolls F; H, a pulverizer, preferably a ball-pulverizer, which has for its purpose to reduce the ore to a finely-divided or comminuted state; I, a conduit for conducting the ore from the discharge of the rolls F to the pulverizer; J, a tank for containing the cyanid solution or other solvent used in the operation of the apparatus; K, a conduit, preferably valved, which leads from the tank J and has discharges disposed over the rolls E and F, this to effect a mixture of the solution and ore incident to the grinding of the latter by said rolls; L, a conduit, preferably valved, which leads from the conduit K to the pulverizer H and has for its purpose to supply solution to the pulverizer, and thereby assure the ore being ground exceedingly fine in the presence of the solution; M, a measuring device or meter of any suitable description arranged in the conduit K between the solution-tank J and the conduit L; N, an ore-feeding device of any suitable description controlling the discharge of the bin B; P, a counter-shaft from which the pump M and the ore-feeding device N are driven, this to assure a supply of solution to the rolls E and F and the pulverizer H commensurate with the quantity of ore discharged from the bin B; Q Q, agitation-tanks, of which six are preferably employed, said tanks being arranged one below the other and being provided with discharge-conduits R, so as to enable the mixed solution and comminuted ore to flow by gravity from the tank nearest the pulverizer H to the next lower tank, and so on until they reach the last tank—i. e., the lowest tank and that farthest from the pulverizer, from which they flow to the filter, presently described; S, a conduit, preferably valved, leading from the conduit L to the agitation-tank No. 1—i. e., the uppermost tank of the series—and designed to supply said tank with the cyanid or other solution
1156 employed; T, a suitable sand-pump interposed between and connected to the pulverizer H and the agitation-tank No. 1 and having for its purpose to move the solution and comminuted ore from the former to the latter; U, a filter arranged to receive the comminuted ore and solution from the last of the agitation-tanks Q—i. e., tank No. 6—and having for its purpose to separate the solution from the pulp; V, a decanting-vat comprising a plurality of separate tanks designed to receive separate solutions from the filter U; W, one or more gold-tanks—i. e., storage-tanks for the gold solution—arranged to receive from the vat V; X, one or more zinc boxes—i. e., boxes arranged to receive from the tank or tanks W and filled with zinc shavings, on which the gold precipitates; Y, a sump-

tank or plurality of tanks arranged to receive solution from the zinc box or boxes, and Z a centrifugal or other suitable pump connected with the sump tank or tanks and the tank J and designed to transfer the solution from the former to the latter. When the solution is thus returned to the tank J and cyanid is added thereto, the solution is used again. This materially lessens the cost of operating the apparatus and is advantageous for such reason.

The ore-crusher A, the elevator C, the grinding-rolls E and F, the elevator G, the pulverizer H, the counter-shaft P, the shafts, presently described, of the agitation-tanks Q, the sand-pump T, the filter U, and the pump Z are driven by a suitable motor or motors through the medium of suitable driving connections, which per se form no part of our invention and which we have therefore deemed it unnecessary to illustrate.

In the practical operation of our apparatus it will be observed that the solution is in contact with the ore incident to the grinding of the ore by the rolls E and F and incident to the reduction of the ore to a finely divided or comminuted state in the pulverizer H. By virtue of this and the subsequent violent agitation of the comminuted ore and solution in the tanks Q the solution reaches all of the values no matter how small the particles of ore in which the same are contained, with the result that when but a weak cyanid solution or other solvent is employed an extraction of from ninety-five per cent. to ninety-eight per cent. of values is effected in from two to six hours, and this without any subsequent concentration of the tailings. The reduction of the ore to a finely divided or comminuted state—i. e., a pulverized state—in the presence of the solution employed assures the solution contacting with every particle of ore, as stated, and thereby accelerates the extraction of the values, and it is also advantageous since less power is required to grind wet ore than dry ore and because it does away with dust and lessens the wear and tear on the machinery. It will also be observed that the ore reduced to a pulverized state and the solution commingled therewith pass continuously and freely through the apparatus, which contributes materially to the thorough extraction of values from the ore. In this connection we desire it understood that we do not confine ourselves to the means shown and described for reducing the ore to a comminuted state in the presence of the solution employed, as any means may be employed for this purpose without involving a departure from the scope of our invention.

From the last of the agitation-tanks—i. e., tank No. 6—the comminuted ore and solution pass to the filter U, where the solution is separated from the pulp and washes are applied to the latter to produce weaker solutions. The pulp is discharged from the filter as tailings, while the solutions separated from the pulp are piped or otherwise conducted to separate tanks of the vat V. Here the slimes in suspension are allowed to settle and are drawn off at the lower ends of the decanting-tanks, while the clear solution flows off at one end and adjacent to the top of the vat V and is led to the precipitating-tank.

Having described the general construction and operation of our

improved apparatus, we will now proceed to a detailed description of the agitation-tanks Q, filter U, and decanting-vat V.

The tanks Q are similar in construction, and hence a detailed description of the one shown in Figs. 2 and 3 will suffice to impart an understanding of all. Referring therefore to Figs. 2 and 3, *a* is a cylinder fixed in the center of the tank Q and having a vent *b* adjacent to its upper end; *c*, a piston movable vertically in the cylinder and having a rod *d* extending through the upper end or head thereof; *e*, a shaft connected by a step *f* or other means with the rod *d*, so as to enable it to move vertically with and rotate independently of said rod *d*; *g*, a miter-gear to which the shaft *e* is keyed or feathered and through which said shaft is adapted to move vertically; *h*, a head connected to the shaft *e*, so as to turn and move vertically therewith; *i i*, agitating-blades connected together and to the head *h* and curved in the direction of their length and inclined in the direction of their width, Figs. 2 and 3, whereby they are adapted to throw the comminuted ore and solution outward after the manner of a centrifugal pump and upward like a plow; *j j*, stationary wings connected to the side wall of the tank and having for their purpose to force the mixture of comminuted ore and solution back to the center of the tank when the same is thrown outwardly by the blades *i*, and *k* a pipe let into the cylinder *a* below the piston *c* and designed, in common with the pipes *k* of the other cylinders Q, to be connected with a source of fluid-pressure supply. When the shaft *e* is rotated by a driving connection intermeshed with the miter-gear *g*, it will be observed that the material in the tank will be thrown out-
1157 wardly and upwardly against the wings *j*, which will roll it back into the center of the tank. This is materially advantageous, since in addition to being kept in suspension the material is worked up and down, and consequently the cyanid solution is caused to absorb the necessary oxygen and effect a rapid and complete dissolution of the gold and silver contained in the ore.

It is desirable in the event of a stop in the operation to raise the agitator means—that is, the blades *i* and the parts to which they are connected—of the several tanks Q out of the mixture or pulp therein. This, in virtue of our improvements, may be accomplished by an attendant opening a valve (not shown) controlling communication between a source of fluid-pressure supply and the pipes *k*, for it will be seen that when fluid-pressure is let into the cylinders *a* of the tanks Q the pistons *c*, shafts *e*, and agitators *i* of said tanks will be raised. To lower the agitators into the mixture or material in the several tanks, the attendant has but to open a bleeder (also not shown) connected with the pipes *k*, when the agitators will gravitate or settle down into the working position. (Shown in Fig. 2.)

It will be appreciated from the foregoing that both the raising and lowering of the agitators in the tanks Q may be quickly and easily effected without involving effort on the part of the attendant of the apparatus, which is a desideratum.

The filter U is best shown in Figs. 4 to 7, referring to which *l* is the main frame of the filter, which preferably comprises a base and two longitudinal uprights and is provided at the upper sides of the

latter with parallel longitudinal ways *m*, Figs. 5 to 7; *n n*, transverse shafts journaled in the uprights of the frame at the ends thereof and equipped with sprocket-wheels *p*, arranged in alinement with the ways *m*; *r r*, sprocket-chains mounted on the wheels *p* and having their upper stretches disposed in the ways *m*; *s*, an endless filter-cloth; *t t*, endless strips of rubber or other suitable material secured to the inner side of the cloth *s* at the edges thereof and having for their purpose to bear on the upper edges of the longitudinal frame-uprights, and thereby prevent frictional wear of the cloth; *u u*, arms connected to the chains *r* at intervals in the length thereof and extending inwardly therefrom; *v v*, links which connect the filter-cloth and rubber belts to the arms *u*; *w w*, transverse rolls of wood or other suitable material mounted in the frame-uprights below the upper stretch of the filter-cloth and arranged, by preference, in three sets, as best shown in Fig. 4; *x x*, idler sprocket-wheels disposed above and in engagement with the upper stretches of the chains *r* and having for their purpose to hold the chains down on sprocket-gears *y* on the rolls *w*, so as to assure the rotation of the rolls in the direction indicated by arrow by the chains; *z z*, transverse rolls arranged in three sets above the rolls *w* and the upper stretch of the filter-cloth *s* and designed to be pressed by screws *a'* or other means toward the filter-cloth; *b' b'*, rolls, one of which is employed in conjunction with each set of rolls *z*; *c' c'*, screws, the purpose of which is to hold the upper bearing-blocks of the rolls *b'* on the lower slidable bearing-blocks thereof; *d' d'*, screws for adjusting the bearings of the rolls *b'* in the direction of the length of the filter and adjustably fixing the same in position; *e' e'*, belts of rubber or other suitable material passed around the rolls *z* and *b'* and having their lower stretches arranged in frictional contact with the filter-cloth *s*; *f' f'*, receptacles arranged under the three sets of rolls *w* and designed to be connected by pipes *g'* with the separate decanting-tanks of the vat V; *h' h'*, pipes designed to be connected with a source of water-supply and arranged to spray water against the stretches of the rubber belts *e'* between the filter-cloth *s* and the rolls *b'*; *i' i'*, pipes arranged to spray water against the lower stretch of the filter-cloth *s*; *j'*, a rotary beater arranged adjacent to the pipes *i'* and adapted to engage the lower stretch of the cloth *s*; *k'* a transverse roller arranged above the lower stretch of the cloth *s* and adjacent to the beater and having its ends journaled in disks *l'* off the center thereof, the disks being arranged in straps *m'* and provided with handles *n'*; *p'*, a transverse roll arranged below the lower stretch of the cloth *s*; *q*, a weighted transverse roll arranged above the lower stretch of cloth *s*, and having for its purpose to squeeze the same against the roll *p'*, and *r'* a rotatable spreader arranged above the upper stretch of the cloth *s* at the receiving end of the filter. One of the shafts *n* of the filter is designed to be driven by a suitable motor, (not shown,) while the beater *j'* is preferably driven from an overhead counter-shaft. (Also not shown.)

The operation of the filter U in detail is as follows: The chains *r* and filter-cloth *s* are driven in the direction indicated by arrow and the beater *j'* is rotated. The rubber belts *e'* are driven in the direction indicated by arrow by the friction between them and the filter-

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cloth. The pulp and solution are discharged from the last agitation-tank—i. e., tank No. 6—through pipe R into the spreader, which has flights extending right and left from the center and is consequently adapted to keep the pulp and solution mixed and spread the same uniformly across the filter-cloth. The filter-cloth carries the mixed pulp and solution under the first set of press-rolls *z*, where the first rubber belt *e'* presses the solution through the filter-cloth. This solution, which is strong, is received in the first receptacle *f'* and is carried by the pipe *g'* to one of the decanting-tanks of the vat V. As it leaves the first set of press-rolls most of the pulp adheres to the first belt *e'*. It is, however, washed down to the cloth by the spray
1158 of water from the adjacent pipe *h'*, which also dilutes the values left as moisture in the pulp. The mixed pulp and water then passes under the second set of press-rolls *z*, where the second belt *e'* passes the solution, which is of medium strength, through the filter-cloth. This solution is received in the second receptacle *f'* and conducted by the pipe *g'* thereof to a tank of the vat V separate from that in which the first solution is placed. In leaving the second set of press-rolls the pulp is watered by the pipes *h'* adjacent to the second belt *e'*, and the pulp and water are carried below the third set of press-rolls. Here the weak solution, produced by the mixture of pulp and water, is pressed through the cloth *s* and received in the third receptacle *f'*, from whence it is conducted by the pipe *g'*, complementary to said receptacle, to a separate tank of the vat V. After leaving the third set of press-rolls the pulp is forced from the cloth by the water discharged by the pipes *i'* and the beater *j'* and is discharged as tailings from the filter through a launder a^2, which may extend to a dump or any other point. After being acted on by the beater *j'* the cloth *s* passes between the squeeze-rolls *p' q'*, which serve to press the water from the cloth, with the result that the same returns to the receiving end of the filter in a clean and dry state. By turning the disks *l'*, and thereby raising or lowering the roller *k'*, the filter-cloth is carried toward or from the beater *j'* to increase or diminish the action of the beater on the cloth.

It will be readily appreciated from the foregoing that the construction of our improved filter is such that the slimes are effectually prevented from collecting and packing down on the filter-cloth and preventing the passage of the solutions therethrough, also that by virtue of the chains traveling in ways or grooves in the frame and being connected to the filter-cloth the filter-cloth is spread out and always held in proper position with respect to the press-rolls and belts *e'*, which conduces to the thorough separation of the solution from the pulp.

As best shown in Fig. 8, the vat V is divided by transverse partition-walls a^3 into a plurality of separate decanting-tanks a^4. These tanks are designed to receive the solutions from the receptacles *f'* of the filter U, and each of them is provided at its lower end with a steep funnel a^5, which is provided in turn at its lower end with a hose a^6. The hose of each tank is normally closed by a clamp, Fig. 9, which comprises a fixed member a^7, connected to the funnel and disposed at one side of the hose, and a pivoted member a^8, connected

to the final tunnel and disposed at the opposite side of the hose with reference to the member a^7 and normally held in the position shown by a weight a^9. When the solutions from the filter U are led into the tanks of a^4 of the vat V, the slimes settle into the funnels a^5 and are drawn off at intervals into a trough a^{10}, while the clear solution passes through one or more conduits a^{11} at one end of the vat to the gold-tank W. When desirable, the members a^8 of the clamps of the several tanks a^4 may be connected together, so that all of the clamps may be opened in concert and slimes discharged from all of the tanks at one time.

The construction described for controlling the discharge of slimes from each of the decanting-tanks is materially advantageous, since there is no liability of the pulp choking the hose, the opening and closing of the hose serving to keep the pulp loose.

We prefer in practice to use a pump M^7 and a conduit M^9 to return the slimes discharged from the tanks a^4 to the lowermost of the agitation-tanks or to the filter, this in order to pass the slimes through the filter the second time and recover the solution contained therein. The conduit M^9 preferably leads from the receptacle or trough a^{10} to the pump M^7 and thence to the lowermost agitation-tank, as shown in Fig. 1.

It will be appreciated from the foregoing that in virtue of the fine grinding our improved apparatus will treat to advantage high or low grade pyritic and telluride ores without a preliminary roast, as the fine grinding frees the particles of gold inclosed in the pyrites and renders the telluride and other compounds of gold more amenable to the cyanid solution.

The spreader r' is arranged in a box r^7, which preferably has an apron r^9. The spreader is a six-sided shaft having wooden flights or wings r^{10} on its sides, the wings at one side of the center of the shaft being inclined oppositely to those at the opposite side of the center. The spreader is driven by belt from an overhead counter-shaft. (Not shown.)

We have entered into a detailed description of the construction and relative arrangement of the parts embraced in the present and preferred embodiment of our invention in order to impart a full, clear, and exact understanding of the same. We do not desire, however, to be understood as confining ourselves to such specific construction and relative arrangement of parts, as such changes or modifications may be made in practice as fairly fall within the scope of our invention as claimed.

Having described our invention, what we claim, and desire to secure by Letters Patent, is—

1. In an apparatus for extracting precious metals from their ores, means whereby ore is reduced to a finely-divided or comminuted state in the presence of a solvent, a series of overflow-tanks arranged to receive the mixed ore and solvent from the reduction means; said tanks containing means for agitating the ore and solvent, and a filter arranged to receive the mixed ore and solvent from the last of the overflow-tanks, and adapted to separate the solution from the ore.

1159 & 1160 2. In an apparatus for extracting precious metals from their ores, means for reducing ore to a finely-

divided or comminuted state, means for supplying a cyanid or other suitable solution to the ore incident to the said reduction thereof, a series of overflow-tanks arranged to receive the mixed ore and solution from the reduction means, and equipped with means for agitating the ore and solution, means for supplying solution alone to the first of said tanks, and a filter arranged to receive the mixed ore and solution from the last of the tanks, and adapted to separate the solution from the ore.

3. In an apparatus for extracting precious metals from their ores, the combination of a tank for containing a cyanid or other suitable solution, means for reducing ore to a finely-divided or comminuted state, one or more conduits connected with the solution-tank and arranged to supply the ore with solution incident to the reduction thereof, means for agitating and mixing the ore and solution, arranged to receive the same from the reduction means, a filter arranged to receive the ore and solution from the agitating and mixing means, and adapted to separate the solution from the ore, one or more decanting-tanks arranged to receive the solution or solutions from the filter, a precipitating-tank which receives the clear solution from the decanting tank or tanks, and means for transferring the solution from the precipitating-tank back to the solution-tank.

4. In an apparatus for extracting precious metals from their ores, the combination of an ore-bin, an ore-feeding device controlling the discharge of the bin, means for reducing ore to a finely-divided or comminuted state, arranged to receive from the bin, a tank for containing a cyanid or other suitable solution, a conduit connected with said tank and arranged to supply the ore with solution incident to the reduction thereof, a measuring device controlling said conduit, and a common means for actuating the ore-feeding device and the solution-measuring device.

5. In an apparatus for extracting precious metals from their ores, the combination of an ore-bin, an ore-feeding device controlling the discharge of the bin, means for reducing ore to a finely-divided or comminuted state, arranged to receive from the bin, a tank for containing a cyanid or other suitable solution, a conduit connected with said tank and arranged to supply the ore with solution incident to the reduction thereof, a measuring device controlling said conduit, a common means for actuating the ore-feeding device and the solution measuring device, a series of overflow-tanks containing means for agitating and mixing the ore and solution, a conduit for conveying solution to the first of the overflow-tanks, a pump arranged to raise ore and solution from the reduction means to the first of the overflow-tanks, a filter arranged to receive ore and solution from the last of the overflow-tanks, and separate the solution from the ore, one or more decanting-tanks arranged to receive a solution or solutions from the filter, a precipitating-tank which receives the clear solution from the decanting tank or tanks, and means for transferring the solution from the precipitating-tank back to the solution-tank.

6. In an apparatus for extracting precious metals from their ores, the combination of an ore-bin, means for reducing ore to a crushed state, arranged to receive from the bin, means for controlling the discharge of ore from the bin, a tank for containing a cyanid or

other suitable solution, a conduit connected to the tank and arranged to supply the ore with solution incident to the reduction thereof, means for controlling the passage of solution through said conduit, and a common means for operating the means for controlling the discharge of the ore from the bin, and the means for controlling the passage of the solution through the conduit, whereby the supply of solution is commensurate with the supply of ore.

7. In an apparatus for extracting precious metals from their ores, means whereby ore is reduced to a pulverized state in the presence of a solvent, means for agitating the mixed ore and solvent, means for separating the solution from the ore, decanting means for receiving the solution from the separating means, and a precipitating-tank for receiving solution from the decanting means.

8. In an apparatus for extracting precious metals from their ores, a solvent source of supply, means whereby ore is reduced to a pulverized state in the presence of solvent from the source of supply, means for agitating the mixed ore and solvent, means for separating the solution from the ore, decanting means for receiving the solution from the separating means, a precipitating-tank for receiving solution from the decanting means, and means for conducting the solution to the source of supply.

9. In an apparatus for extracting precious metals from their ores, means for separating solution from ore, decanting means receiving solution from the separating means, and means for returning slimes from the decanting means to the separating means.

10. In an apparatus for extracting precious metals from their ores, the combination of means for separating solutions from mixed ore and solvent, and separate decanting devices for receiving the solutions from the separating means.

In testimony whereof we have hereunto set our hands in presence of two subscribing witnesses.

JOHN STOVEKEN.
LEO STOVEKEN.

Witnesses:
WM. H. TABOR.
JAMES A. McCANDLESS.

1161 [DEFENDANT'S EXHIBIT DRAWING AND SPECIFICATION OF LETTERS PATENT NO. 735,071, PATENTED AUGUST 4, 1903, ISSUED TO G. D. DELPRAT.]

(Here follows diagram marked p. 1162.)

1163 No. 735,071, Patented August 4, 1903.

United States Patent Office.

GUILLAUME D. DELPRAT, of Broken Hill, New South Wales, Australia.

Extraction of Zinc, Lead, and Silver Sulfids from Their Ores.

Specification Forming Part of Letters Patent No. 735,071, Dated August 4, 1903.

Application Filed January 2, 1903. Serial No. 137,586. (No specimens.)

To all whom it may concern:

Be it known that I, Guillaume Daniel Delprat, general manager of the mines and works of the Broken Hill Proprietary Company, Limited, of Victoria, a subject of the Queen of the Netherlands, residing at Broken Hill, in the State of New South Wales and Commonwealth of Australia, have invented new and useful Improvements in the Extraction of Zinc, Lead, and Silver Sulfids from Their Ores, of which the following is a specification.

This invention relates to the extraction or concentration of sulfid ores to separate them from their gangue.

The ore is first finely ground or stamped and then immersed or dropped into a bath or solution, hereinafter described. An apparatus for carrying out the process forms the subject-matter of a separate application, filed March 9, 1903, Serial No. 146,895. This process is readily carried out at ordinary temperatures and depends upon the ore particles being attacked by the acid to form a gas. Each ore particle so attacked will have a bubble or bubbles of gas adhering to it, by means of which it will be floated and can be skimmed or floated off the solution. The particles of the gangue, such as silicates and other substances not quickly or readily attacked by acid or dilute acid, fall to the bottom of the body of the solution and are removed from time to time. To facilitate the floating of the ore particles, suitable salts are added to the solution to increase its specific gravity, as will be hereinafter explained.

No. 735,071. PATENTED AUG. 4. 1903.

G. D. DELPRAT.

EXTRACTION OF ZINC, LEAD, AND SILVER SULFIDS FROM THEIR ORES.

APPLICATION FILED JAN. 2, 1903.

NO MODEL.

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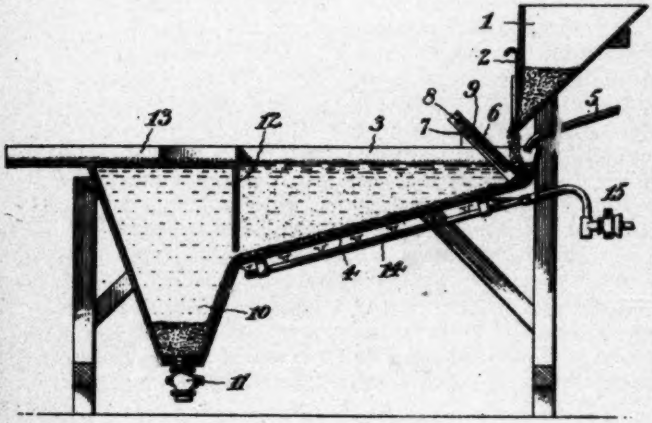


Witnesses:
Walter
E. Beall.

Inventor:
Guillaume Daniel Delprat.

by Henry Orth & Co.

In extracting or concentrating, more especially the sulfid ores of zinc, lead, and silver, I make use of a nitric-acid solution, the gravity of which is increased to one and four-tenths, (1.4,) more or less, by the addition of a suitable nitrate, such as an alkaline-metal nitrate, as the nitrate of soda nitrate of potash, or another metallic nitrate, as the nitrate of zinc dissolved in water, or a mixture of nitrates. The sulfids in the ore are rapidly acted upon by the acid and gas-bubbles formed on them, that quickly carry them to the surface, whence they flow away or are removed by skimming. The tailings or waste may be removed from the bath from time to time, as is necessary or expedient.

The drawing shows in vertical longitudinal section the apparatus used.

Below an ordinary bin or hopper 1, having a regulating discharge-door 2, is the pan or vessel 3, having a sloping bottom 4. The liquor or chemical solution is supplied by pipe 5 from a suitable reservoir (not shown) at an upper level. Just below the door 2 is a plate 6 on pintles or pivots 7 in slots 8, adapted to be clamped by set-screws 9 when the plate is adjusted to the required angle and with the required extent of opening between the lower edge of said plate 6 and the bottom 4, the directing-plate being, primarily, to insure the total immersion of all particles of ore in the fluid or liquor. At the lower end of the inclined bottom 4 is a tailings-receiver or sump 10, having a tailings-discharge 11. At the receiving end of the sump 10 is a baffle-plate 12, extending close to the face of said bottom 4, the object of which is to prevent accumulation of concentrates above the sump 10. Extending from the pan 3 is a launder or trough 13 to receive the overflow and the concentrates. Under the bottom 4 is a piping 14, forming, with the air-inlet cock 15, a Bunsen burner for gas, so that the solution or liquor may be heated, if desired. The ore fed from the hopper 1 drops into the bath and slides by gravity over the bottom to the sump, the ore particles being raised to the surface of the liquor by the gas-bubbles formed, the action of the acid on these ore particles during their travel along the inclined bottom and ore floated off with the overflow through the trough 13, or, if desired, skimmed off.

Having thus described my invention, what I claim as new therein, and desire to secure by Letters Patent, is—

1. The method of separating ores from gangue, which consists in forming a bath containing nitric acid, feeding finely-ground ore thereto, whereby gas-bubbles will be formed on the ore particles to raise them to the surface of the solution, and removing the particles of ore so lifted to the surface, substantially as described.

1164 2. The method of separating ores from gangue, which consists in forming a bath containing nitric acid and a suitable nitrate, feeding finely-ground ore thereto, whereby gas-bubbles will be formed on the ore particles to lift them to the surface and removing the ore particles so raised, substantially as described.

3. The method of separating sulfid ores from their gangue, which consists in forming a bath containing nitric acid, increasing the gravity of the bath by adding thereto the nitrate of an alkaline

metal, whereby gas-bubbles will be formed on the ore particles to raise them to the surface, and floating off the particles of ore so raised to the surface, substantially as described.

4. The method of separating sulfid ores from their gangue, which consists in forming a bath containing nitric acid, adding thereto sodium nitrate to increase the specific gravity of the bath, feeding the finely-ground ore into the bath, whereby gas-bubbles will be formed on the surface of the ore particles to raise them to the surface of the bath and floating off the ore particles so raised, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

GUILLAUME D. DELPRAT.

Witnesses:
FRED WALSH.
PERCY NEWELL.

No. 736,381. PATENTED AUG. 18, 1903.

M. F. R. GLOGNER.

PROCESS OF PURIFYING GRAPHITE.

APPLICATION FILED JAN. 27, 1903.

NO MODEL.

Fig. 1.

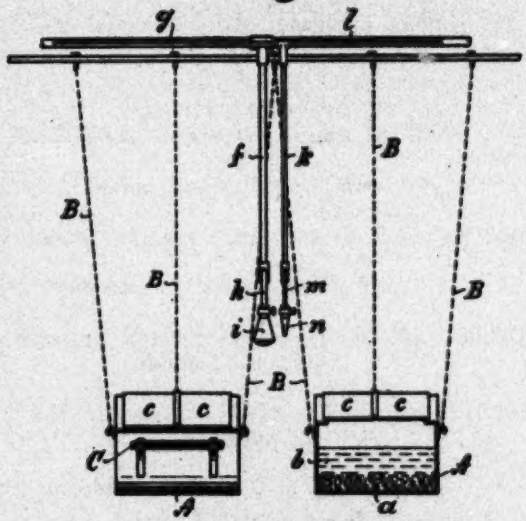
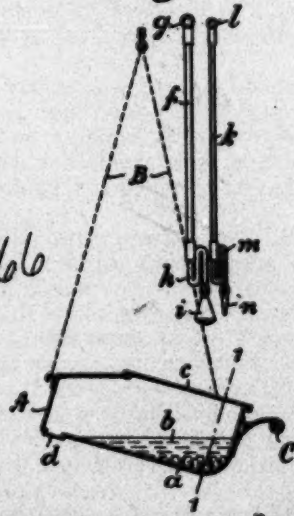


Fig. 2.



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Witnesses
H. M. Kuehne
Paul Neuhart

Inventor
C. Moritz Friedrich Reinhold Glogner
by Richards & Co.

1165 [DEFENDANT'S EXHIBIT DRAWING AND SPECIFICATION OF LETTERS PATENT NO. 736,381, PATENTED AUGUST 18, 1903, ISSUED TO M. F. R. GLOGNER.]

(Here follows diagram marked p. 1166.)

1167 No. 736,381. Patented August 18, 1903.

United States Patent Office.

MORITZ FRIEDRICH REINHOLD GLOGNER, of Freiburg, Germany.

Process of Purifying Graphite.

Specification Forming Part of Letters Patent No. 736,381, Dated August 18, 1903.

Application Filed January 27, 1903. Serial No. 140,786. (No specimens.)

To all whom it may concern:

Be it known that I, Moritz Friedrich Reinhold Glogner, a subject of the King of Prussia, German Emperor, residing at Freiburg, in the Kingdom of Prussia, German Empire, have invented certain new and useful Improvements in Processes of Purifying Graphite; and I do hereby declare that the following is a full, clear, and exact description.

The present invention relates to a process for purifying graphite from its natural mineral impurities, which process is especially adapted to be carried out on a manufacturing scale, because, on the one hand, it is very simple and cheap, and, on the other hand, the final result is very good and far superior to any obtainable by processes hitherto employed.

In my new process after being purified in a first wash from its heavier impurities—as, for instance, quartz, iron, and the like—by means of cold water the graphite mineral is mixed with about three or four times its weight of water to a thin paste. A quantity of petroleum is then added to this paste, which quantity is about half as much as the amount of pure graphite contained in the graphite mixture, and the whole is thoroughly stirred within a closed vessel. Afterward the vessel is allowed to stand, and water is sprinkled over the surface of the liquid by means of a rose or the like in order to obtain a quicker and more complete separation of the graphite particles from the earthy admixtures.

In my present invention I desire first to point out that the graph-

ite mixture as submitted to the process of purification by means of water and petroleum consists, exclusively, of graphite and earthy admixtures. Only by this means is the quick and complete purification of the graphite by means of the subsequent treatment rendered possible. If the graphite were to be purified by means of water and petroleum while the heavier admixtures are still present, a far greater amount of petroleum, as well as of labor, would be necessary, yet a complete separation of the graphite from its admixtures would be impossible. The product obtained thus would not be pure. The high degree of purity, however, determines the value of the product.

For carrying out my new process preferably a plurality of agitating or shaking devices are arranged close to each other, one workman being sufficient for attending four of them.

Figure 1 of the accompanying drawings illustrates two agitating devices arranged close to each other, one apparatus being shown in elevation and the other in a section on line 11 in Fig. 2. Fig. 2 represents a longitudinal section of an agitating apparatus.

Each agitator A is obliquely suspended on three chains B in such a manner that the wave formed when the vessel is agitated falls back on the higher part of the bottom and a thorough mixing of oil and graphite is obtained, the operation being at the same time facilitated. Each vessel A has a handle C.

a is graphite filled in a wet state.

b is the water with the layer of oil.

c c are covers.

d is an outlet-hole for the pulpy residue—for instance, a handhole with a cover, a door, or the like. The tube *f* is in connection with a water-supply *g* and fitted with a flexible tube *h* and a rose *i*. The tube *k* is connected with an oil-supply *l* and also fitted with a flexible tube *m*, leading to a mouthpiece *n*.

The devices are preferably operated by human force, because the treatment of the material is utterly difficult, and a throughout special treatment is required for each of the large number of varieties of the material.

Before the graphite is brought into the vessels A it is separated from its heavier admixtures—as quartz, iron, and the like—which in the well-known manner is effected by washing the material with water in long kennels. Exactly-weighted quantities of the material which thus contains only graphite and earthy admixtures are brought into the vessels A. Then, first water is admitted from the tube *h* and later oil from the tube *m*.

The vessels A are agitated in short shocks, about thirty per minute. After the agitation has taken place the mixture of oil and graphite floating at the surface is subjected to a uniform action of the rose, whereafter the vessel is allowed to stand in order to obtain the separation of the earthy parts. After the attendant has operated four agitators in the described manner the dirty water in the first vessel has become clear in the meantime. The workman 1168 takes off the oil-graphite and puts it into a collector for the further treatment in order to obtain in any well-known manner a separation of the oil from the graphite.

The mixture containing only fine earthy substances and graphite is mixed with a quantity of water the weight of which is about three or four times as great as that of the graphite mixture. Petroleum is then added in the approximate proportion of one part petroleum to two parts of graphite contained in the mixture. Now the whole is given a strong rotating, rocking, or reciprocating movement within a closed vessel, so that the mixture is thoroughly stirred and intimately mingled. The petroleum is broken up into very fine drops or perles, and every graphite particle when touching them is attracted, while the earthy particles, which were already saturated with water before the addition of petroleum, remain completely neutral. After the vessel has been allowed to stand the earthy parts sink down, while the petroleum carrying the graphite tends to rise to the surface. After a certain time water is then sprinkled over the surface of the liquid by means of a rose or the like, whereby the fine earthy particles are caused to sink more quickly, and any earthy particles which may be carried upward by the rising petroleum and froth are caused to sink down again.

The vessel is shaken once, twice, or repeatedly after the graphite has been skimmed, and every time some petroleum is added. The whole of the graphite will then be taken off by the petroleum.

In the described manner the graphite is quickly, well, and cleanly separated from its earthy admixtures. The product obtained is of best quality and purity, yet the amount of petroleum and labor needed is insignificant. It is even rendered possible by my process to work graphite mixtures which only contain ten per cent. graphite and to obtain from them a product which is as valuable as the Ceylon graphite.

My new process is furthermore especially adapted for the purification of the small dense crystalline varieties of graphite, for which a commercial purifying process has not existed up to the present time.

Having now described my invention and in what manner the same is to be performed, what I claim, and desire to secure by Letters Patent, is—

A process for purifying graphite in a wet and cold manner by the use of water and petroleum, consisting in the following operations: purifying the graphite mineral from its heavy admixtures (as for instance quartz, iron and the like) by a washing with cold water; mixing said purified graphite mineral with about three or four times its weight of cold water; very strongly agitating said paste within a closed vessel after the addition of a quantity of petroleum of about half the weight of the pure graphite contained in the mixture; and then sprinkling water over the surface of the liquid, after the mixture has been allowed to stand, in order to obtain a quicker and more complete separation of the graphite particles from the earthy substances, substantially as described.

In witness whereof I have hereunto set my hand in presence of two witnesses.

MORITZ FREIDRICH REINHOLD GLOGNER.

Witnesses:

ERNST. KRATZ.

ALBERT SCHENK.

1169 [DEFENDANT'S EXHIBIT DRAWINGS AND SPECIFICATIONS OF LETTERS PATENT NO. 745,960, PATENTED DECEMBER 1, 1903, ISSUED TO I. F. GOOD.]

(Here follow diagrams marked pp. 1170 and 1171.)

1172 No. 745,960. Patented December 1, 1903.

United States Patent Office.

ISRAEL F. GOOD, of Allentown, Pennsylvania, Assignor of One-half to GEORGE FRANCIS PETTINOS, of Bethlehem, Pennsylvania, and JOHN HERBERT HARRIS, of Allentown, Pennsylvania.

Apparatus for Separating Graphite or Other Materials from Associated Impurities.

Specification Forming Part of Letters Patent No. 745,960, Dated December 1, 1903.

Application Filed October 1, 1902. Serial No. 125,532. (No model.)

To all whom it may concern:

Be it known that I, Israel F. Good, a citizen of the United States, residing at Allentown, in the county of Lehigh and State of Pennsylvania, have invented a new and useful Apparatus for Separating Graphite or other Materials from Associated Impurities, of which the following is a specification.

This invention relates to an apparatus for separating graphite and other materials from associated impurities.

The object of the invention is in a ready, simple, rapid, thoroughly-feasible, and practical manner initially to separate pure graphite from any associated impurities and conserve it and then to effect saving of the bulk of whatever remains in the impurities separated out.

With these and other objects in view, as will appear as the nature of the invention is better understood, the same consists in the novel construction and combination of parts of an apparatus for separating graphite and other materials from associated impurities, as will be hereinafter fully described and claimed.

In the accompanying drawings, forming a part of this specification, and in which like numerals of reference indicate corresponding parts, there is illustrated one form of embodiment of the invention capable of carrying the same into practical operation, it being understood that the elements therein exhibited may be varied or changed

No. 745,960. PATENTED DEC. 1, 1903.

I. F. GOOD.

APPARATUS FOR SEPARATING GRAPHITE OR OTHER MATERIALS FROM ASSOCIATED IMPURITIES.

APPLICATION FILED OCT. 1, 1903.

NO MODEL. 2 SHEETS—SHEET 1.

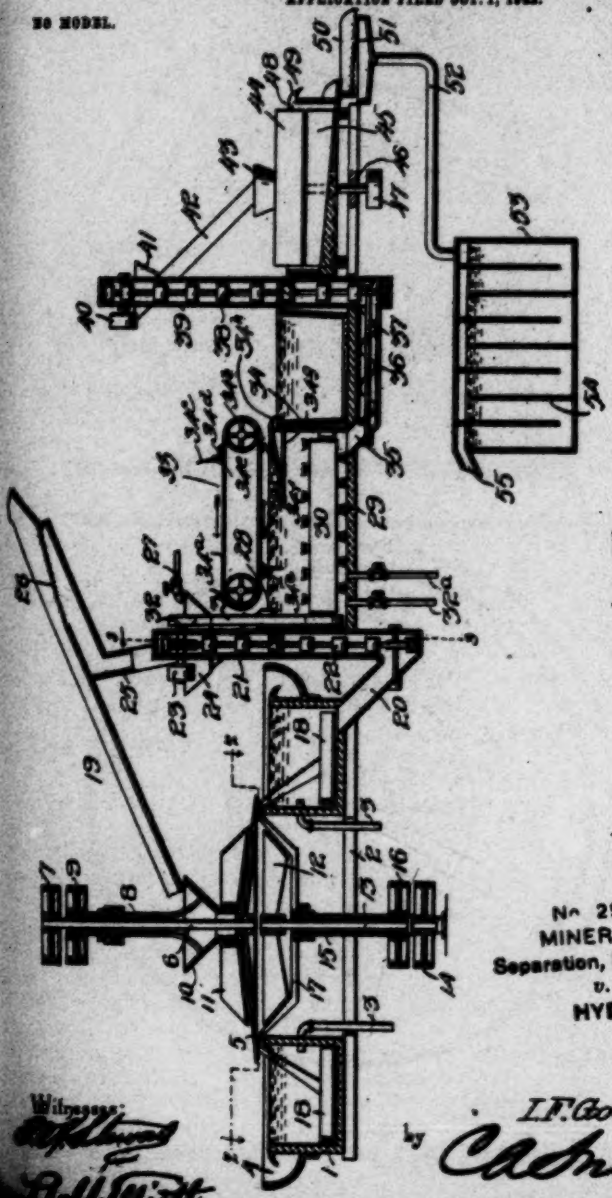

Fig. 1.

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Witnesses:
[illegible]

I. F. Good,
by C. A. Snow & Co.
Attorneys.

No. 745,960. PATENTED DEC. 1, 1903.

I. F. GOOD.

APPARATUS FOR SEPARATING GRAPHITE OR OTHER MATERIALS FROM ASSOCIATED IMPURITIES.

APPLICATION FILED OCT. 1, 1902.

NO MODEL. 2 SHEETS—SHEET 2.

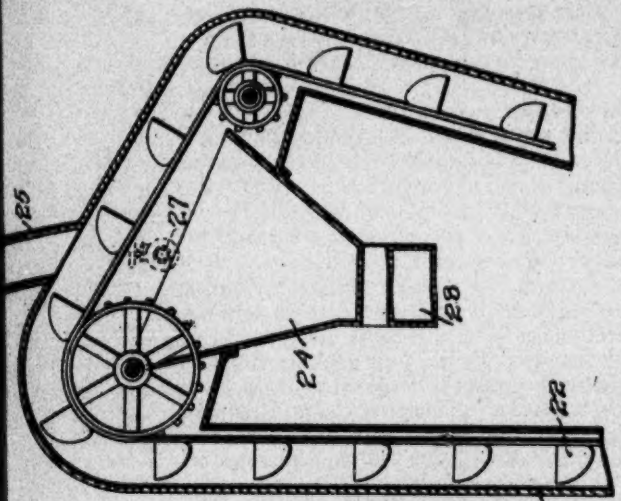

Fig. 3.

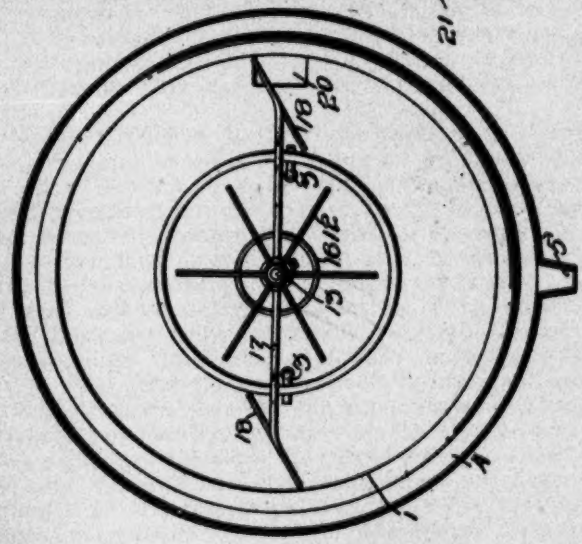

Fig. 2.

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Witnesses:
R. H. Stewart
[illegible]

I. F. Good, Inventor:
by C. A. Snow & Co.
Attorneys.

as to shape, proportion, and exact manner of assemblage without departing from the spirit thereof.

In the drawings, Figure 1 is a view in vertical longitudinal section through an apparatus constructed in accordance with the present invention. Fig. 2 is a view in longitudinal section taken on the line 2 2 of Fig. 1 and looking in the direction of the arrow thereon. Fig. 3 is a view in sectional elevation, on an enlarged scale, taken on the line 3 3, Fig. 1, showing more particularly the conveying mech-nism for elevating the impure materials from the primary separating-tank to the washing mechanism.

Referring to the drawings, 1 designates an annular tank constituting the primary separating-tank, the same being suitably supported upon a bed 2 and containing water supplied thereto by the pipes 3. The upper portion of the tank is surrounded by a trough 4, having a discharge-spout 5. (Clearly shown in Fig. 2.) Disposed above the tank, with its periphery overlapping the inner walls thereof, is an upward-dished disk 5, which is rigidly mounted upon a shaft 6, driven from a pulley 7 through a belt, (not shown,) and inclosing the shaft 6 is a tubular shaft 8, carrying at its upper end a pulley 9 and at its lower end a hopper 10 and a fan 11, the latter being disposed over the disk and rotating in a direction opposite thereto. The fan 11 produces a current of air which is mainly directed horizontally outward, but of which a small portion is directed downward owing to the vertical divergence of the blast, so producing a slight downward pressure upon the upwardly-dished disk 5, the utility of which will be hereinafter explained. Disposed below the disk is a second fan 12, rigidly secured to a shaft 13, driven by a pulley 14, and inclosing the shaft 13 is a tubular shaft 15, carrying at its lower end a pulley 16 and at its upper end a pair of arms 17, which are bent to project downward into the tank and carry at their terminals scrapers or stirrers 18.

Disposed over the hopper 10 is a chute 19, down which the finely-powdered rock, sand, or earth containing the graphite or other materials is fed. Thence it passes into the hopper and down upon the disk 5, where the finer particles or flakes of graphite are retained by the slight downward pressure of the blast of air from the fan 11, while the coarser portions drop into the tank 1. The flakes caught by the disk 5 under centrifugal action due to the rotation of the disk are discharged outward and upon the surface of the water contained in the tank, this action being assisted by the blast of air from the fan 12, which impinges the discharge of finely-divided graphite as it escapes in a sheet from the periphery of the disk and operates to spread it out over the water and also to impel it laterally to the trough 4, whence it escapes through the spout 5 and is caught in a suitable receptacle. The coarser portions of the graphite, rock, and sand or dirt mixed therewith are forced out of the tank and down an outlet 20, the scrapers 18, as shown in Fig. 2, being preferably disposed tangentially to their path of movement, thus to prevent the material from banking up against the inner wall of the tank, as will be readily understood. Communicating with the outlet 20 is a casing 21, housing an ordinary conveyer 22, driven from a pulley 23,

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and this conveyer elevates the material and discharges into a hopper 24. (Shown in detail in Fig. 3.) Communicating with the hopper is a spout 25, tapped into the chute 19, the mouth of the spout being covered by a fine screen 26 to effect separation of the finer particles of graphite which mix with the materials elevated by the conveyer 22. In the hopper the material has oil, either coal-oil or any other suitable kind, sprayed upon it from a pipe 27, and the mixed graphite, sand, &c., escapes through a chute 28 into a washing-tank 29, containing a rotary agitator 30, driven by a belt 31 from the upper shaft 32 of the conveyer 22, the water of the tank 29 being kept at boiling heat by steam supplied through pipes 32^a. The lighter particles of graphite separated by the agitator and that float on the surface of the water in the washing-tank are removed by a skimming device 33 and are discharged into a tank 34, containing water, whence they are removed. The skimming device comprises a belt 34^a, supported by two pulleys 34^b, disposed in horizontal alinement above the tank 29, one of the pulleys being driven by any suitable means, not necessary to be shown. Secured at regular intervals to the belt are curved arms 34^c, which are in length equal to the width of the tank, which latter is rectangular in shape, the arms being hinged to keepers 34^d, secured to the belt, a spring 34^e, coacting with each arm, operating normally to cause it always to occupy a position at right angles to the belt, while permitting it to yield, as indicated by dotted lines. The tank has associated with the upper portion of its rear end an inclined plate 34^f, supported in the tank by a plate 34^g, the outer end of the plate 34^b being projected over the upper edge of the tank to constitute a lip 34^h. As the belt is rotated the arms or skimmer elements 34^c travel along the upper surface of the material contained in the tank and convey it to the plate 34^f, up which it is pushed, the incline of the said plate operating to cause the arm to be folded inward toward the belt, as shown; but as soon as it passes the lip 34^h the arm will resume its normal position.

The coarser portions of the graphite and any sand or the like remaining in the washing-tank pass down an outlet 35 into a conduit 36, in which is arranged a screw conveyor 37, which feeds the material to a second bucket conveyer 38, arranged in a housing 39, the conveyer being driven by a pulley 40, revolved by a belt, not necessary to be shown. The material elevated by the conveyer 38 is discharged into a hopper 41, thence passes through a chute 42 into the hopper 43 of a muller comprising two circular blocks of wood 44 and 45, the latter being stationary and the former being revolved by a shaft 46, driven by a pulley 47. The mulling-blocks are arranged within a tank 48, containing water and provided with a spout 49, which discharges into a trough 50, having a screen 51 to separate the sand, &c., from the graphite, the trough having connected with it a pipe or conduit 52, which connects with a settling-tank 53 of the usual construction. As the upper muller-block is rotated it operates to reduce the graphite to a pasty mass, which settles in the tank 53, whence it is removed, the tank being provided with the usual baffle-plates 54 common to such structures and with an overflow-spout 55.

The operation of this machine is extremely rapid and is contin-

nous and effects in a thoroughly efficient and practical manner the separation of the graphite from any associated impurities.

Having thus described the invention, what I claim as new is—

1. An apparatus of the character specified, comprising a rotary receiving-table, and pneumatic means for holding the finer particles of graphite thereon while the coarser portions escape.

2. An apparatus of the character specified, comprising a rotary receiving-table, pneumatic means for holding the finer particles of graphite thereon while the coarser portions escape, and pneumatic means for impelling the finer particles laterally to a point of discharge.

3. An apparatus of the character specified, comprising an upward-dished receiving-table, a fan disposed above the table for holding the finer particles of graphite thereon while the coarser portions escape, and a fan disposed beneath the table for impelling the finer particles to a point of escape.

4. An apparatus of the character specified, comprising an annular tank, a rotary upward-dished receiving-table projecting over the tank, a fan disposed respectively above the table and rotating in the direction opposite that of the table, and rotary scrapers disposed within the tank.

5. An apparatus of the character specified, comprising means for separating the finer graphite from any associated impurities, means for conserving the finer particles, a washing-tank embodying agitating mechanism, means for conveying the residuum to the washing-tank, means for mixing oil with said residuum before being discharged into the washing-tank, a skimmer device associated with the tank to remove the finer particles from the tank, a muller,
1174 means for conveying the coarser particles from the washing-tank to the muller, and a settling-tank communicating with the muller.

6. An apparatus of the character specified, comprising an annular tank having a peripheral trough associated therewith, an upwardly-dished receiving-table having its periphery disposed over the tank, blast mechanism disposed above and below the table and rotating in a direction opposite thereto, a hopper associated with the upper blast mechanism, rotary stirrers disposed within the tank, a washing-tank, conveying mechanism communicating with the annular tank and discharging into the washing-tank, a chute for discharging the coarser portions of graphite to the hopper of the upper fan and the finer particles to the washing-tank, means for supplying oil to the mixed finer and coarser portions before entry into the washing-tank, agitating and skimming mechanism associated with the washing-tank, a muller, conveying mechanism communicating with the washing-tank and discharging into the muller, and a settling-tank in communication with the muller.

In testimony that I claim the foregoing as my own I have hereto affixed my signature in the presence of two witnesses.

ISRAEL F. GOOD.

Witnesses:
PETER G. CONRAD.
DAVID T. HISKEY.

1175 [DEFENDANT'S EXHIBIT DRAWING AND SPECIFICATION OF LETTERS PATENT No. 768,035, PATENTED AUGUST 23, 1904, ISSUED TO G. D. DELPRAT.]

(Here follows diagram marked p. 1176.)

1177 No. 768,035. Patented August 23, 1904.

United States Patent Office.

GUILLAUME D. DELPRAT, of Broken Hill, New South Wales, Australia.

Extracting Zinc or Other Sulfids from Their Ores.

Specification Forming Part of Letters Patent No. 768,035, Dated August 23, 1904.

Application Filed January 2, 1903. Serial No. 137,585. (No Specimens.)

To all whom it may concern:

Be it known that I, Guillaume Daniel Delprat, a subject of the Queen of the Netherlands, residing at Broken Hill, in the State of New South Wales and Commonwealth of Australia, have invented certain new and useful Improvements in Extracting Zinc or other Sulfids from Their Ores, of which the following is a specification.

The finely-divided ores are immersed in a hot but preferably not boiling solution of salt cake or of sodium sulfate and sulfuric acid, and the sulfids rise to the top and are skimmed off or otherwise removed.

A suitable apparatus for carrying out the process is shown in section in the accompanying drawing.

Below an ordinary bin or feed-hopper 1, having a regulating discharge-door 2, is the pan or vessel 3, having a sloping bottom 4. The liquor or chemical solution is supplied by pipe 5 from a suitable reservoir (not shown) at an upper level. Just below the door 2 is a plate 6 on pintles or pivots 7 in slots 8, adapted to be clamped by set-screws 9 when the plate is adjusted to the required angle and with the required extent of opening between the lower edge of said plate 6 and the bottom 4, the directing-plate being primarily to insure the total immersion of all particles of ore in the fluid or liquor. At the lower end of the inclined bottom 4 is a tailing-receiver or sump 10, having a tailings-discharge 11. At the receiving end of the sump 10 is a baffle-plate 12, extending close to the face of said bottom 4,

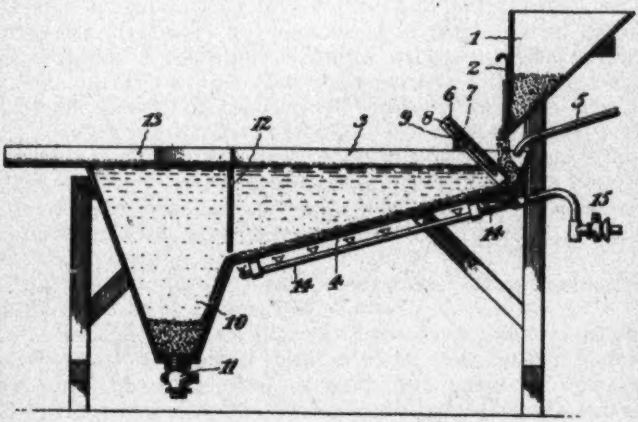
No. 768,035. PATENTED AUG. 23, 1904.

G. D. DELPRAT.

EXTRACTING ZINC OR OTHER SULFIDS FROM THEIR ORES.

APPLICATION FILED JAN. 2, 1903.

NO MODEL.



No. 259
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Page 1176

Witnesses:
Wm. Ober
A. Lemmers

Inventor
Guillaume Daniel Delprat
by Henry Orth & Co.
Attys.

the object of which is to prevent accumulation of concentrates above the sump 10. Extending from the pan 3 is a launder or trough 13 to receive the overflow and the concentrates. Under the bottom 4 is piping 14, forming with the air-inlet cock 15 a Bunsen burner for gas, so that the solution or liquor may be raised to any desired temperature. The ore fed from the hopper 1 drops into the heated bath and slides by gravity over the bottom to the sump, the ore particles being raised by the gas-bubbles to the surface of the liquor during the travel of the ore over the inclined bottom and are floated off with the overflow through the trough 13 or, if desired, skimmed off. This apparatus forms the subject-matter of a separate application for patent filed March 9, 1903, Serial No. 146,895, to which I therefore make no claim in this application.

In practice the "sulfid ores," including in such term the products and waste from other metallurgical processes, are finely pulverized, as well understood, and are then ready for immersion in the hot bath. This bath consists of a solution of salt cake in water of a specific gravity approximating to 1.4 (one and four-tenths,) which is kept hot, but preferably is not allowed to boil. As an alternative the bath consists of a solution of sodium sulfate in water, to which is added free sulfuric acid, so that the resultant will approximate the stated specific gravity of 1.4 (one and four-tenths,) and this bath is also kept heated and likewise preferably not allowed to boil. As the ore immerses itself in the heated bath the sulfids with gas-bubbles of sulfureted hydrogen attached disengage themselves from the gangue, rising to the top, whence they may flow away or be skimmed off. The tailings or waste may be removed from the bottom of the sump at intervals as desired.

Having thus described my invention, what I claim as new therein, and desire to secure by Letters Patent, is—

1. The method of separating ores from their gangue, which consists in forming an aqueous solution of an acid capable of reacting with the ore to form a gas and increasing the density of said solution by adding thereto a suitable substance, then feeding the mixture of ore and gangue to the solution, decreasing the density of the gas as it is formed on the ore particles, and removing the ore particles raised to the surface, substantially as described.

2. The method of separating ores from their gangue, which consists in forming a solution of a suitable acid capable of reacting with the ore to form a gas, increasing the density of the solution by adding thereto a suitable salt soluble therein, then feeding the mixture of ore and gangue to the solution and decreasing the density of
1178 the gas as it is formed, whereby the size of gas-bubbles will be increased and the ore raised to the surface of the solution, substantially as described.

3. The method of separating ores from their gangue, which consists in forming a solution of an acid capable of reacting on the ore to form a gas, and increasing the density of said solution by a suitable substance, then feeding the finely-ground mixture of ore and gangue to the solution and finally removing the ore particles raised to the surface, substantially as described.

4. The method of separating sulfid ores from their gangue, which consists in forming a solution containing sulfuric acid, and adding thereto a substance soluble therein and capable of increasing the density of the solution, feeding fine ore thereto capable of reacting with sulfuric acid to generate a gas and thereby raise the ore to the surface, and removing the ore so raised to the surface, substantially as described.

5. The method of separating sulfid ores from their gangue, which consists in forming a solution of sulfuric acid and a sulfate, maintaining the solution heated below the boiling-point, feeding finely-ground ore thereto, whereby the acid will react with the soluble sulfid-ore particles present to form sulfureted hydrogen and be lifted by bubbles of said gas to the surface of the solution, and removing the ore so carried to the surface of the solution, substantially as described.

6. The method of separating sulfid ores from their gangue, which consists in forming a solution of sulfuric acid and sodium sulfate, maintaining the solution heated below the boiling-point, feeding finely-ground ore thereto, whereby the acid will react with the soluble sulfid-ore particles present to form sulfureted hydrogen and be lifted by bubbles of said gas to the surface of the solution, and removing the ore so carried to the surface of the solution, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

GUILLAUME D. DELPRAT.

Witnesses:
FRED WALSH.
PERCY NEWELL.

No. 771,075. PATENTED SEPT. 27, 1904.

C. KENDALL.

SEPARATION OF MINERAL SUBSTANCES BY MEANS OF THE SELECTIVE ACTION OF OIL.

APPLICATION FILED JULY 21, 1903.

NO MODEL. 2 SHEETS—SHEET 1.

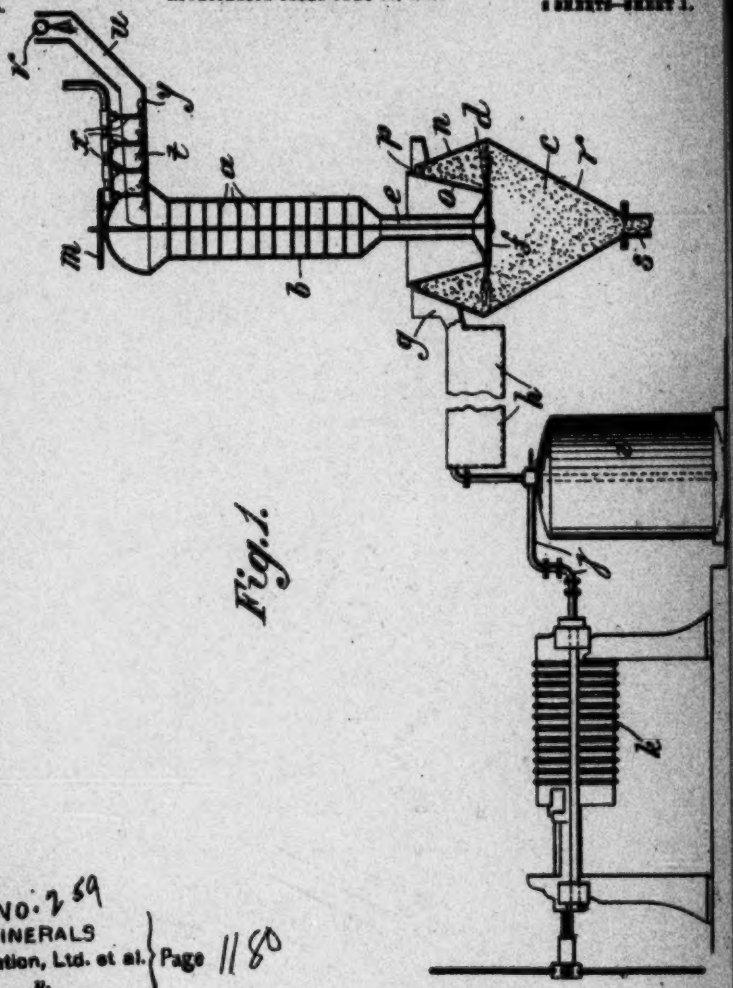

Fig. 1.

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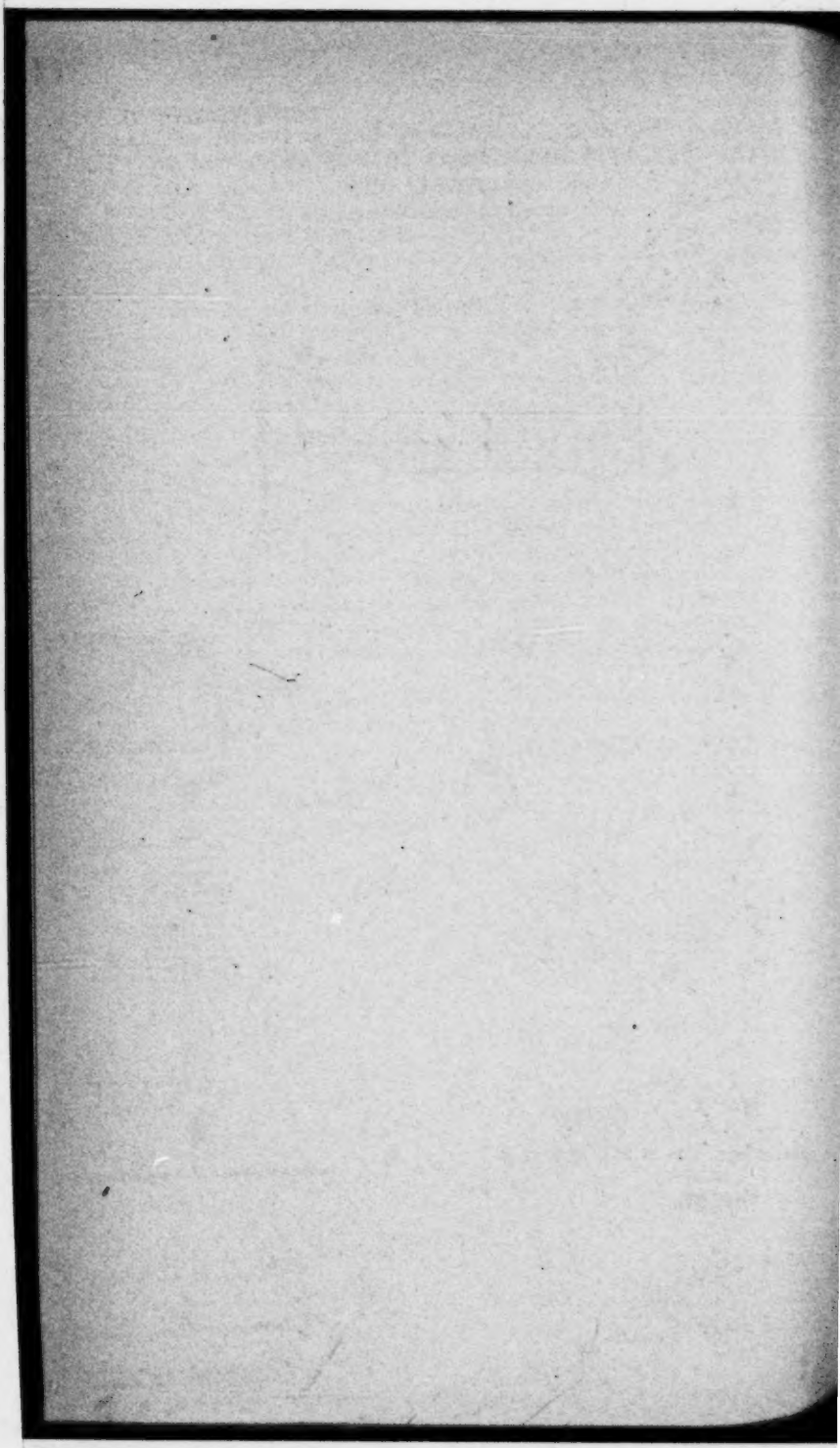
v.
HYDE.

Witnesses
Edna P. Wright Jr.
Alice M. Chumley

Inventor
Cosmo Kendall,
By A. J. Patten,
Atty



No. 771,075. PATENTED SEPT. 27, 1904.

C. KENDALL.

SEPARATION OF MINERAL SUBSTANCES BY MEANS OF THE SELECTIVE ACTION OF OIL.

APPLICATION FILED JULY 21, 1903.

NO MODEL. 2 SHEETS—SHEET 2.

Fig. 2

Fig. 3.

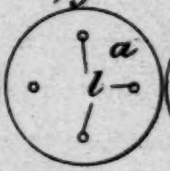


Fig. 4.

Fig. 5

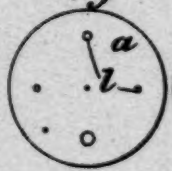


Fig. 6.

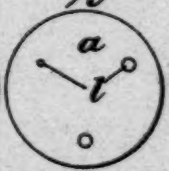


Fig. 7.

Fig. 8.

Fig. 9.

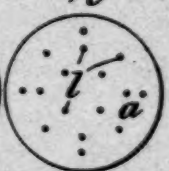


Fig. 10.

Fig. 11.

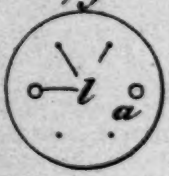


Fig. 12.

Fig. 13.

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Witnesses
Chas. F. Wright Jr.
Alice M. Cumming

Inventor
Cosmo Kendall,
By A. S. Pattison,
Atty.

1179 [DEFENDANT'S EXHIBIT DRAWINGS AND SPECIFICATION OF LETTERS PATENT NO. 771,075, PATENTED SEPTEMBER 27, 1904, ISSUED TO C. KENDALL.]

(Here follow diagrams marked p. 1180 and 1181.)

1182 No. 771,075, Patented September 27, 1904.

United States Patent Office.

COSMO KENDALL, of Upper Norwood, England.

Separation of Mineral Substances by Means of the Selective Action of Oil.

Specification Forming Part of Letters Patent No. 771,075, Dated September 27, 1904.

Application Filed July 21, 1903. Serial No. 166,484. (No Specimens.)

To all whom it may concern:

Be it known that I, Cosmo Kendall, a subject of the King of Great Britain and Ireland, residing at Upper Norwood, in the county of Surrey, England, have invented Improvements in the Separation of Mineral Substances by Means of the Selective Action of Oil, of which the following is a specification.

According to this invention crushed graphite-containing material—for example, graphite ore or graphite waste—is mixed with water and brought intimately into contact or thoroughly mixed with pure thin oil—as, for example, kerosene or paraffin oil—which adheres to and by reason of its levity separates the graphitic substance (this may be more or less pure graphite) from associated rocky matter, which by reason of its weight and non-affinity to oil sinks in and is conveniently carried off by the water. The graphitic substance is or may be afterward separated from the oil and the latter is or may be used again in subsequent similar operations. In separating graphitic substances in this way I do so or may do so by means of apparatus and in the manner that I will now describe. The crushed graphite-containing material mixed with water and oil is supplied to an agitator or mixer adapted to produce a thorough mixing of the materials under the action of gravity alone, and from this agitator or mixer the mixture passes in the form of a thin sheet or thin sheets or the like (preferably annularly and horizontally) and at a considerable velocity into a vessel, which is initially filled with water or water

and oil and is of such a shape and has the material discharged into it in such a position as to enable water and rocky matter or gangue to pass off at an outlet or outlets at or near the bottom and the oil to carry the graphitic substance up with it to the surface, whence the mixture flows off to have the graphitic substance separated from foreign matter, including it may be the oil, in any suitable manner.

In one example of the treatment of graphite-containing material according to this invention the apparatus is employed that is shown diagrammatically in the accompanying drawings, whereof—

Figure 1 is a diagrammatical general sectional elevation of the apparatus, and Figs. 2 to 13, inclusive, are plans of twelve disks used therein.

The crushed material mixed with water and oil is supplied to an agitator or mixer comprising a number of disks or other plates *a*, perforated or made foraminous and horizontally disposed, spaced apart, and fixed within a vertical casing *b*. Below the agitator or mixer there is a vat *c*, containing water, into which the mixture is projected in a thin horizontal annular sheet *d* from a vertical pipe *e*, the lower end of which is, say, twenty-four inches below the top of the vat and is provided with a valve-like device *f*, by means of which at the bottom of the pipe *e* an annular outlet of, say, twenty-four inches in diameter is formed and which can be adjusted in depth by means of a hand-wheel *m* to vary the cross-sectional area of the outlet. The oil and the graphitic substance carried by it rise to the surface of the water in the vat and flow over the rim of the vat into an inclined launder *g*, from which they flow into a settling-tank *h*, (or series of settling-tanks or into a vessel similar to that above described). From the settling tank or tanks the surface matter flows into a closed receptacle *i*, whence it can be forced by means of compressed air through a pipe *j* into a filter-press *k*. The plates *a* of the agitator or mixer have their perforations so arranged and shaped that different portions of the materials will be caused to flow at different rates within the agitator or mixer, and will consequently become thoroughly mixed.

Figs. 2 to 13, inclusive, are plans of the twelve disks employed in the apparatus shown and show relative sizes and an arrangement of the perforations *l* thereby by means of which the effect desired can be attained. The total area of the perforations *l* in each disk *a* is equal to the cross-sectional area of the narrowest portion of the pipe plus an amount necessary to compensate for friction. The vat *c* is so
1183 shaped that inclined surfaces *n* and *o* deflect the ascending oily matter into a constricted annulus *p* of, say, a diameter of forty-eight inches and a width of an inch and a half, and another inclined surface *r* deflects the falling water and rocky matter or gangue toward an outlet *s*, which is centrally arranged and is, say, forty-eight inches below the bottom of the pipe *e*. The oil may be mingled with the material to be treated as it is borne to the top of the agitator or mixer through a channel *t* by a sufficiency of water supplied to it in a conduit *u*, as through perforations in a pipe *v*, the oil passing into the mixture through a number of fine orifices arranged to discharge beneath the moving mass of material. The oil may

thus be supplied by a number of pipes x, which are at right angles to the direction of flow of the material and have perforations to discharge the oil in the same direction as that of the material and each of which has behind it an inclined plane y, adapted to direct the material to be treated slightly upward and over the perforations of the corresponding oil-pipe x. The rocky matter or gangue issuing from the vat may be passed to another and similar agitator or mixer for like treatment if necessary. The remaining oil in the cakes of the filter-press may be partly or wholly displaced by a subsequent water wash, and thereby partly or wholly recovered.

It will be understood that the dimensions hereinbefore stated may be varied in accordance with the quantity of material to be treated in a given time, and they are given only by way of example, having been found suitable in practice.

What I claim is—

1. The hereinbefore-described process for the treatment of finely-divided material for the separation of graphitic substance contained therein from associated rocky matter or gangue, consisting in mixing said material with water, bringing said material intimately into contact or thoroughly mixing it with suitable pure thin oil, as kerosene or parafin oil, projecting at a considerable velocity the mixture so produced under the surface of a volume composed of said material, water, and oil, allowing oil and graphitic substance adhering thereto to pass upward to said surface, and drawing off from said surface oil and graphitic substance immediately on arrival at said surface.

2. The hereinbefore-described process for the treatment of finely-divided material for the separation of graphitic substance contained therein from associated rocky matter or gangue, consisting in mixing said material with water, bringing said material intimately into contact or thoroughly mixing it with suitable pure thin oil, as kerosene or paraffin oil, projecting horizontally or substantially horizontally the mixture so produced under the surface of a volume composed of said material, water, and oil, allowing oil and graphitic substance adhering thereto to pass upward to said surface, and drawing off from said surface oil and graphitic substance immediately on arrival at said surface.

3. The hereinbefore-described process for the treatment of finely-divided material for the separation of graphitic substance contained therein from associated rocky matter or gangue, consisting in mixing said material with water, bringing said material intimately into contact or thoroughly mixing it with suitable pure thin oil, as kerosene or paraffin oil, projecting at a considerable velocity the mixture so produced under the surface of a volume composed of said material, water, and oil, allowing oil and graphitic substance adhering thereto to pass upward to said surface, drawing off from said surface oil and graphitic substance immediately on arrival at said surface, and forcing matter so drawn off into a filter-press so as to recover oil.

4. The hereinbefore-described process for the treatment of finely-divided material for the separation of graphitic substance contained therein from associated rocky matter or gangue, consisting in mixing said material with water, bringing said material intimately into con-

tact or thoroughly mixing it with suitable pure thin oil, as kerosene or paraffin oil, projecting horizontally or substantially horizontally the mixture so produced under the surface of a volume composed of said material, water, and oil, allowing oil and graphitic substance adhering thereto to pass upward to said surface, drawing off from said surface oil and graphitic substance immediately on arrival at said surface, and forcing matter so drawn off into a filter-press so as to recover oil.

5. The hereinbefore-described process for the treatment of finely-divided material for the separation of graphitic substance contained therein from associated rocky matter or gangue, consisting in mixing said material with water, bringing said material intimately into contact or thoroughly mixing it with suitable pure thin oil as kerosene or paraffin oil, projecting in the form of a thin sheet and at a considerable velocity the mixture so produced under the surface of a volume composed of said material, water, and oil, allowing oil and graphitic substance adhering thereto to pass upward to said surface, and drawing off from said surface oil and graphitic substance immediately on arrival at said surface.

6. The hereinbefore-described process for the treatment of finely-divided material for the separation of graphitic substance contained therein from associated rocky matter or gangue, consisting in mixing said material with water, bringing said material intimately into contact or thoroughly mixing it with suitable pure thin oil, as
1184 kerosene or paraffin oil, projecting horizontally or substantially horizontally in the form of a thin sheet and at a considerable velocity the mixture so produced under the surface of a volume composed of said material, water, and oil, allowing oil and graphitic substance adhering thereto to pass upward to said surface, and drawing off from said surface oil and graphitic substance immediately on arrival at said surface.

Signed at London, England, this 10th day of July, 1903.

COSMO KENDALL.

Witnesses:

H. D. JAMESON.

A. NUTTING.

No. 776,145. PATENTED NOV. 29, 1904.

C. V. POTTER.

PROCESS OF SEPARATING METALS FROM SULFID ORES.

APPLICATION FILED JAN. 14, 1903.

NO MODEL.

Fig. 1.

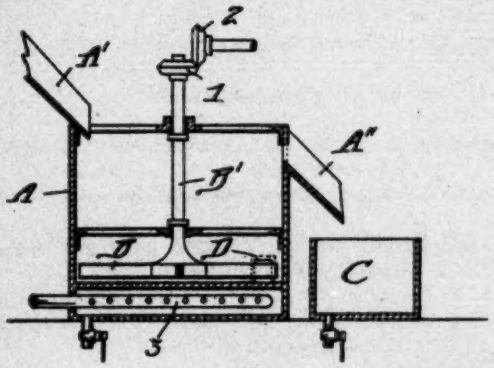
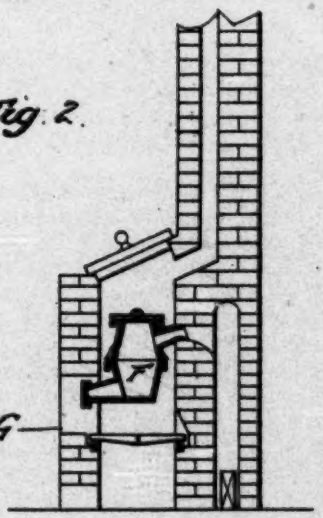


Fig. 2.



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MINERALS
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v.
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Witnesses:
C. A. Middleton
J. B. Middleton

Inventor
Charles V. Potter
By Pickands & Co.
Attys

1185 [DEFENDANT'S EXHIBIT DRAWING AND SPECIFICATION OF LETTERS PATENT NO. 776,145, PATENTED NOVEMBER 29, 1904, ISSUED TO C. V. POTTER.]

(Here follows diagram marked p. 1186.)

1187 No. 776,145, Patented November 29, 1904.

United States Patent Office.

CHARLES VINCENT POTTER, of Balaclava, Victoria, Australia.

Process of Separating Metals from Sulfid Ores.

Specification Forming Part of Letters Patent No. 776,145, Dated November 29, 1904.

Application Filed January 14, 1902. Serial No. 89772. (No Specimens.)

To all whom it may concern:

Be it known that I, Charles Vincent Potter, engineer, a British subject, and a resident of 43 The Avenue, Balaclava, in the State of Victoria, Commonwealth of Australia, have invented an Improved Process of Separating Metals from Sulfid Ores, of which the following is a specification.

The object of my invention is to separate metals from sulfid ores by an expeditious, effective, and inexpensive means and method.

The crude ore, concentrates, tailings, or slimes after being pulverized are placed in a suitable vat or vessel and a solution is then added, such solution consisting of water with the addition of from one per cent. to ten per cent. of any acid, (preferably sulfuric acid, for reasons hereinafter stated,) the acidulated strength of the solution being determined by the quality or nature of the sulfid ore to be treated. The small quantity of acid added does not act as a solvent.

Ores containing lead, zinc, copper, iron, gold, and silver in combination with sulfur I treat as follows: The ore in a state of fine division is placed in a vat or such like vessel provided with an internal stirrer or stirrers. The acidulated solution is then added thereto, such solution containing in the first instance, say, one per cent. only of the acid when mixing it with the ores, and after heat is applied thereto, as hereinafter directed, gradually increasing its acidulated strength until the determinate strength is reached, which in most instances will amount to two and a half per cent. of acid, or thereabout, to be decided on or governed by the apparent action

of the solution on the material under treatment. Heat being applied, the effect of the acidulated solution becomes apparent by the bubbling up and gathering on the surface of the fluid of the metallic concentrates in the form of a pasty mass. Should this pasty substance be scanty, thin, and not swell and accumulate rapidly, so as to overflow the vat if not skimmed off, more acid must be added until the maximum separative activity is reached, which very slight experience and observation in applying this treatment to sulfid ores will enable the operator to determine. I use sulfuric acid preferably by reason of its cheapness and its capability of production from a by-product resulting from the process or treatment herein described. While the exact acidulated strength of such solution will depend on the metallic contents and general condition of the ore, ascertainable only by observation when under treatment as aforesaid, any variation of the acidulated strength found necessary or expedient will remain well within the limit before stated—namely, of from one to ten per cent. of the whole solution. The bulk solution to be added or applied to the class of ores lastly named would be, say, approximately two hundred and fifty gallons to every ton weight of ore, varying to some small extent, according to the absorbent quality of the ore and its degree of fineness. The stirrers are then freely used, and heat is applied to the vat or vessel directly or by means of steam injection therein at or near the floor of the vat or vessel. As the temperature of the solution and other contents of the vat or vessel rises it causes the metals to rise upward from the bottom of the vat and float upon the surface, from which it may be allowed to flow automatically and continuously into a separate receptacle or be skimmed off, as arranged, into a separate vessel for further treatment. The gangue accumulating in the bottom of the separating-vat, containing a small proportion of gold and silver, as well as all the rhodonite, garnets, silica, and the like, can be then further treated by cyanid or other of the well-known means or processes and the gold and silver be thus extracted therefrom. The said solution may be used over and over again by the addition from time to time of a small quantity of acid when it is apparent by the effect of the solution when reapplied to the material and heated that its acidulated strength has become diminished. The skimmings or concentrates, containing all the metals free from gangue, are then mixed with a certain quantity of crushed or coarsely broken-up iron or iron oxid,

1188 (the quantity of such iron required depending upon the quantity of sulfur the metals contain,) also a quantity of powdered charcoal. This mixture is then placed in a suitable vessel or retort and a rapidly-produced heat applied, converting the mixture into a molten condition. After a short period it will be found that the sulfid of lead and silver has been reduced to metallic lead and silver. The retort can then be tapped at the bottom and these metals run off. In this step the iron changes places with the lead of the galena, the equation being $PbS+Fe=FeS+Pb$. It will thus take fifty-six pounds of cast-iron to reduce two hundred and thirty-nine pounds of galena to two hundred and seven pounds of

metallic lead. While this reduction is taking place the iron, having changed places with the lead, becomes sulfid of iron, and the zinc by the action of the great heat is vaporized and passed off in the form of vapor into a suitable vessel, wherein it becomes condensed into metallic zinc. The iron sulfid remaining in the retort is recrushed and roasted, the sulfur resulting from which may be utilized for the manufacture of sulfuric acid.

The means or process for treating ores, chiefly for the recovery of the gold therein, in combination with sulfur, such as iron pyrites or arsenical pyrites, is as follows: The ore is ground to a very fine powder, (the finer the better,) placed in a vat or suitable vessel, the said solution added, well stirred, and the heat applied in exactly the same manner as before described in relation to the lead and silver ores, thus separating the gold and other metals from the gangue in manner as before described. The skimmings or concentrates, which are now in a very small bulk containing practically all the gold, are then roasted in a suitable furnace, after which they will be in a condition to be treated by chlorin or cyanid in the well-known manner. By this treatment the difficulties of treating a large bulk of ores mixed with slimes and the necessity for dealing with the slimes by filtration are obviated and dispensed with and a better and more complete result obtained.

The accompanying drawings show, for example, a series of receptacles for carrying out the above-described process, in which—

Figure 1 is a sectional elevation of a vat and the tank, and Fig. 2 is a like view of the retort with its furnace.

In the drawings, A is the vat, having the chute A′ leading thereto, and B indicates the stirrer-arms, secured to a shaft B′, the stirrer-arms being rotated by means of the gearing 12 from a suitable source of power. The vat is shown as being heated by a gas-pipe 3, placed below the bottom of the vat. D is a door in the vat.

C indicates the separate tank, and A″ the chute for allowing the skimmings to flow from vat A to said tank C.

Fig. 2 shows the retort F placed in the furnace G, so as to be heated thereby.

Having now described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. The herein-described process of separating metals from pulverized sulfid ores which consists in adding to the same an acid solution which is a non-solvent of the precious metals, then applying heat to the same, and removing the sulfids from the surface of the solution, substantially as described.

2. The process of separating metals from pulverized sulfid ores, concentrates, and slimes by mixing an acidulated solution therewith which is a non-solvent of the metal to be separated, stirring, heating, skimming or floating off such metals from the surface of the whole admixture as they are carried to the surface so as to recover such concentrates of metals ready for after treatment, as, and in manner hereinbefore described.

3. The method of separating sulfid ores from their gangue, which

consists in forming a suitable solution containing sulfuric acid to react on the soluble sulfids present to form bubbles of sulfereted hydrogen on the ore particles and thereby raise them to the surface, and removing the ore particles so raised, substantially as described.

In witness whereof I have hereunto set my hand in presence of two witnesses.

CHARLES VINCENT POTTER.

Witnesses:
ALFRED FORD.
JONATHAN BEAR.

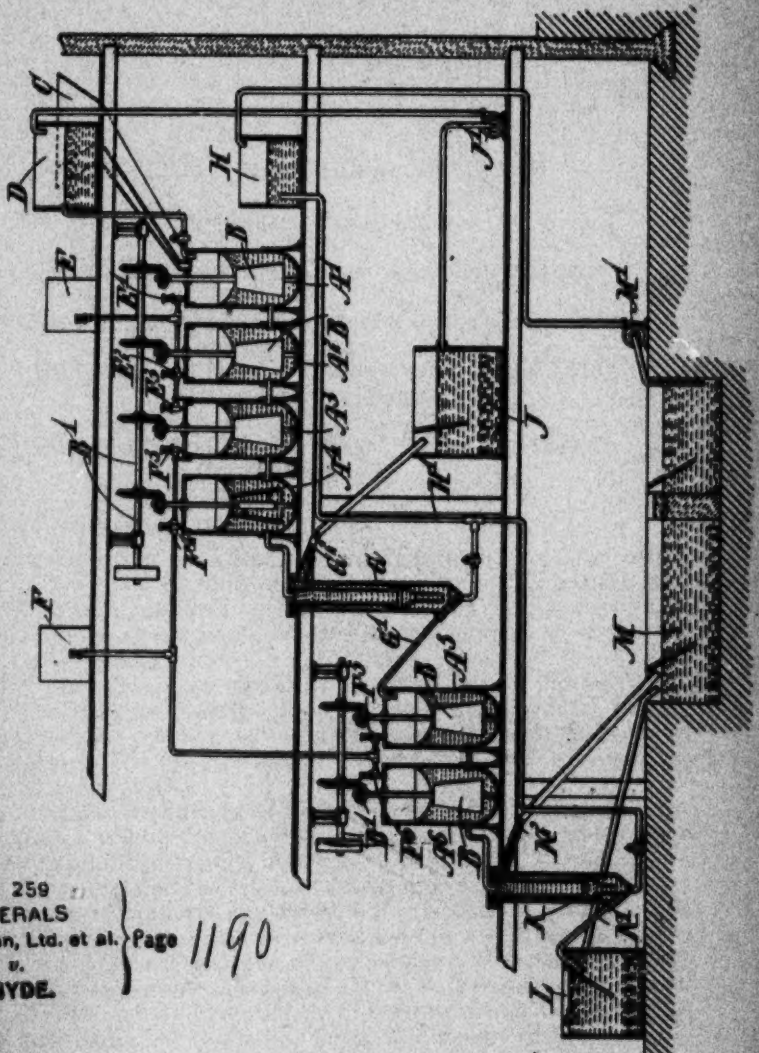
No. 777,273. PATENTED DEC. 13, 1904.

A. E. CATTERMOLE.

SEPARATION OF THE METALLIC CONSTITUENTS OF ORES FROM GANGUE.

APPLICATION FILED SEPT. 28, 1903.

NO MODEL.



No 259
MINERALS
Separation, Ltd. et al. } Page 1190
v.
HYDE.

Witnesses:
Harold Hurd
Mabel Hayes.

Inventor:
Arthur E. Cattermole.
By Knight Bros. Attorneys.

1189 [DEFENDANT'S EXHIBIT DRAWING AND SPECIFICATION OF LETTERS PATENT No. 777,273, PATENTED DECEMBER 13, 1904, ISSUED TO A. E. CATTERMOLE.]

(Here follows diagram marked p. 1190.)

1191 No. 777,273. Patented December 13, 1904.

United States Patent Office.

ARTHUR EDWARD CATTERMOLE, of London, England.

Separation of the Metallic Constituents of Ores from Gangue.

Specification Forming Part of Letters Patent No. 77,273, Dated December 13, 1904.

Application Filed September 28, 1903. Serial No. 174,947. (No Specimens.)

To all whom it may concern:

Be it known that I, Arthur Edward Cattermole, a subject of the King of England, residing at Highgate, London, England, have invented certain new and useful Improvements in the Separation of the Metallic Constituents of Ores from Gangue, of which the following is a specification.

The present invention relates to improvements in the separation of the metalliferous constituents of ores and the like from gangue by means of the selective action of oils and certain tar products or similar compounds (all hereinafter referred to as "oil") on metallic or metalliferous matter.

The invention depends upon the application of the following facts: First, when a mixture of powered metalliferous matter and gangue is treated with oil suspended in water—that is to say, in emulsion—the oil has a more or less selective action and will coat the particles of metalliferous matter in preference to the particles of gangue, while the particles of gangue will be wetted by the water; second, if the water which is mixed with the oil is acidulated with mineral, fatty, or other acid the selective action of the oil will thereby be rendered more marked and decisive; third, if the proportion of oil is kept within reasonably low limits (differing in different cases, according to the nature of the mineral to be treated and the consistency and nature of the oil) and if the mixture of water, oil, metalliferous particles, and gangue be thoroughly agitated the metalliferous particles which have become coated with oil will adhere together and form

granules, which granules, partly by reason of gravity or partly on account of their bulk, as compared with the individual grains of gangue, will offer ready means for separation in an up-current separator, a jig, or other similar appliance. This action is facilitated if the oil before addition to the liquor is brought into the condition of an emulsion in water containing a small percentage of soap or other emulsifying agent. These facts are utilized for the purpose of separating the metalliferous constituents from the gangue of the ore in the following manner: In a suitable apparatus, an example of which will be hereinafter described, the ground or pulped ore is caused to be violently agitated, as by a revolving stirrer, in a mixture of water and oil, the liquor being acid. As the agitation proceeds the particles of metalliferous matter agglomerate together and may be observed in the form of granules, the size of which will depend, among other things, upon the percentage of oil used. This granulation of the metalliferous constituents of the ore affords the means by which at a later stage of the process it is possible to separate the metalliferous material from the gangue, as will be hereinafter particularly described. In practice a continuous process is used—that is to say, water, ground ore, or pulp and oil, preferably emulsified, are continuously fed into a series of vessels, and the products of the agitation are continuously fed into an up-current separator or jig or similar device, which in the case of the up-current separator separates the metalliferous granules from the gangue by allowing them to fall to the bottom of the vessel and to be carried away by a downward stream, while the particles of gangue are carried away by an upward st-eam.

The accompanying drawing is a diagram illustrating in sectional view one means of carrying out the process according to this invention, in which the liquid mass is brought into an acid condition.

A series of connected mixing vessels A′ A^2 A^3 A^4 A^5 A^6 are provided with stirrers B, rotated from driving-shafts B′. Crushed ore from a hopper C and water from a tank D are introduced into the first vessel, A′, and oil o remulsion is fed from a tank E, through pipes E′ E^2 E^3, to the various vessels. The mixture is vigorously agitated to break up and emulsify the oil and to bring about intimate contact of the divided oil with the metalliferous mineral particles and of the oiled particles with each other. It is found under these conditions the metalliferous mineral particles abstract the oil and become coated with a thin oily film, which is insufficient to materially lessen their specific gravity, and that under agitation such slightly-oiled particles adhere, nucleate, and agglomerate into small more or less rounded masses or granules disseminated
1192 throughout the mass of gangue, which remains free and practically devoid of oil. In order to maintain the liquid mass in which the separation is effected in an acid condition, a small proportion of the sulfuric or other acid is introduced into one or more of the vessels from a tank F, having discharge-pipes F^3 F^4 F^5 F^6. After agitation to a certain extent (in four vessels, as illustrated, for example) the mixture is passed into an up-current classifier G, which is supplied with a stream of acidulated water from a

tank H through a pipe H′. As the granules remain specifically heavier than the gangue or can by suitably adjusting the amount of oil and the agitation be obtained of a size larger than that of the gangue particles, the granules, with a certain amount of heavy sands, sink to the bottom and are discharged through a pipe G′ into the vessel A^5, while the lighter sands are carried away by the upward current and discharged through outlet G^2 to a light-sands tank J, from which the water may be returned by a pump J′ to the feed-tank D for reuse. In order to separate the granules from the heavy sands, the mixture is subjected to further agitation in the vessels A^5 A^6 and is then passed into a second classifier K, from which the granules are removed at the bottom by the pipe K′ into the metalliferous-mineral tank L, while the heavy sands are discharged from the upper pipe K^2 into a heavy-sands tank M. The water from the tanks L and M is returned by a pump N′ to the feed-water tank H. This apparatus is illustrated only as one convenient method of carrying out this invention, and it is to be understood that its nature and arrangement can be considerably varied. Thus the acid condition may be obtained by acidulating the ore-pulp before agitation with the oil or oil emulsion, or the ore-pulp may be first agitated with emulsion to slightly agglomerate the ore, which may be settled and washed and the product then treated by agitation with acid solution to granulate the mineral and free the gangue. Which of the methods is most applicable depends upon the nature of the mineral matter and of the gangue, their state of division, and relative proportions. The agitation vessels may be separate, with arrangements for charging and discharging, the charging with pulp and the addition of acid and of oil or emulsified oil and the agitation and discharge successively in the series of vessels being so timed that the output of treated ore is kept continuous and constant. The classifiers used may be jigs, shaking-tables or the like, or sizing apparatus, whereby the comparatively larger mineral granules may be separated from the finer gangue and one or more classifiers may be employed.

The proportion of oil used depends upon its viscosity, the fineness of the ore and other factors, and the consistency and size of the mineral granules desired. The more oil used the larger, softer, and less numerous the granules. With, say ten per cent, of oil to the weight of metalliferous mineral a few pasty masses of oil-agglomerated metalliferous mineral matter will generally result. Oil in excess of this may cause all the granules to coales-e into one soft mass. Usually an amount of oil varying from four per cent. to six per cent. of the weight of metalliferous mineral matter present in the ore yields granules of suitable size, consistency, and specific gravity for ready separation from the gangue in the up-current or other apparatus used for classification.

The amount of emulsifying agent if used to form the oil emulsion depends upon the vi-cosity and nature of the oil. When soap is employed, an amount varying from three per cent. to five per cent. of the weight of oil usually suffices, this being dissolved in, say, ten

times its weight of water. For emulsification a low alkalinity of the emulsifying agent is generally best.

The "oil" used may be animal, vegetable, or mineral oil or mixtures of these or such coal or wood tar products or other substances which exercise, like oils, a preferential physical affinity for metallic mineral matter as distinguished from gangue. The emulsifying agent (if such is used) may be any substance capable of holding the oil in a fine state of division in suspension in water without acting on the mineral matter or preventing the action of the oil—for example, soap, alkaline cresylates, or other substances, solutions of which in water froth on agitation. The emulsifying agent, or the constituents liberated therefrom under the action of acid, appears to have a decided effect in aiding the granulation, as described. In some cases, as with wood-tar and some coal-tar products, these when agitated in weak alkaline solutions provide their own emulsifying agents, soluble resinates, cresylates, &c., being thereby formed which emulsify the bulk of the tar or product. In this process the amount of emulsifying agent employed is kept as low as possible compatible with the proper subdivision of the oil to prevent undue waste of the alkaline or basic constituent present, which is necessarily destroyed in the acid solution used. When soap is used, the fatty acid becomes associated with the mineral granules and can be subsequently recovered. Emulsification in some cases, as with the heavier residuum oils or tars, may be assisted by first mixing therewith a small amount of fatty oil or fatty acid. Preferably one emulsifying agent is employed throughout the process.

In order to recover the oil from the granules after their separation from the gangue, they may be agitated with the emulsifying agent in a stronger or more active condition or proportion than was used in the emulsification of the oils initially, and the action
1193 of this emulsifying agent in stripping the oil from the metalliferous mineral particles may be aided by attrition. The strengthening of the emulsifying agent may be effected by increasing the proportion of the agent or of the alkaline base in solution, or both, the percentage strength of the solution needed depending upon the oil used and the nature of the metalliferous mineral matter with which it is associated. Usually if oleic soap is employed and caustic potash amounts varying from one-quarter of one per cent. to three per cent. or four per cent. of one or the other in solution suffice, the less readily emulsified oils, as the residuum oils, requiring the larger amounts. The removed oil is obtained as a dilute emulsion, which on standing some time separates. The cream or concentrated emulsion may then be used for making fresh emulsion for treating fresh ore. To hasten this separation of "cream," mechanical devices may be employed.

Generally with wet crushed ore removal of the bulk of the water for reuse in the mill is necessary. In such case the pulp is settled and the wet ore only fed into the agitators, acid-water being added to thin them. The circuit of such liquids can thus be kept distinct from that of the mill-water, suitable arrangements being made for

settling the mineral-depleted sands and slime and for addition of acid and fresh water, as required from time to time.

In certain cases, as where but little mineral is present in the ore, to increase the nucleating or granulating factor pulverized mineral matter obtained in a previous operation or other matter having an affinity for oil from a different source may be introduced into the ore, or a portion of already granulated and separated mineral matter may be returned to maintain the necessary amount of mineral in the ore under treatment.

In carrying out the process the ore may be roughly sized into two or more parts, which are then treated separately. With certain ores it may be preferable to use in some stages of the process a rolling form of agitation, as in cylinders or barrels, to obtain good granulation of the mineral.

It has been found that if the water in which the operation is conducted contains a percentage of acid, varying in the case of sulfuric acid of 1.84 specific gravity from one-half of one per cent. to a tenth of one per cent., the operation is greatly facilitated. Indeed, if there is no acid present there is a great tendency for the oil to coat the gangue or some portion of the gangue, as well as the metalliferous particles. It is preferable to use water acidulated with about one-fifth of one per cent. of this acid, and it is found in practice that such a degree of acidulation is sufficient completely to prevent the gangue from being oiled, while it is not, generallly speaking, enough to cause the water to act chemically upon the metalliferous matter.

I am aware that the selective action of oils and the like on metallic matter has been made on the basis of previous processes for separating the metalliferous constituents of ores from gangue. For example, oil has been used to float off metalliferous mineral from ore-pulp, and its use has also been proposed to form a pasty mass of crushed ore from which the gangue could afterward be washed out by means of water, and I do not claim the employment of oil in any such manner.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The herein-described process of separating metalliferous matter from gangue which consists in mixing the pulp with an amount of oil equaling only a fraction of the metalliferous constituents, agitating the mass until the oil-coated metalliferous matter is agglomerated into granules and subjecting the mixture to classification to remove the small non-coated particles from the granules.

2. The herein-described process of separating metalliferous matter from gangue which consists in mixing the ore with an emulsion containing an amount of oil equaling only a fraction of the metalliferous constituents agitating the mass until the oil-coated metalliferous matter is agglomerated into granules and subjecting the mixture to classification to remove the small non-coated particles from the granules.

3. The herein-described process of separating metalliferous matter from gangue which consists in mixing the ore with an emulsion containing an amount of oil equalling only a fraction of the metal-

liferous constituents and an acid, agitating the mass until the oil-coated metalliferous matter is agglomerated into granules and subjecting the mixture to classification to remove the small non-coated particles from the granules.

4. The herein-described process of separating metalliferous matter from gangue which consists in mixing the ore with an emulsion containing an amount of oil equaling only a fraction of the metalliferous constituents and an acid, agitating the mass until the oil-coated metalliferous matter is agglomerated into granules and subjecting the mixture to up-current classification to remove the small non-coated particles from the granules.

5. The herein-described process of separating metalliferous matter from gangue which consists in mixing the ore with an emulsion containing an amount of oil equaling only a fraction of the metalliferous constituents and an acid, agitating the mass until the oil-coated metalliferous matter is agglomerated into granules and separating out the light sands, thereafter further agitating the mass to increase the size of the granules and separating out the heavy sands from the granules.

1194 6. The herein-described process of separating metalliferous matter from gangue which consists in agitating a mixture of powdered ore, oil emulsion and water containing an acid and adding particles of material having an affinity for oil to assist in the formation of granules of oil-coated particles and subjecting the mixture to a classification to remove the small non-coated particles from the granules.

7. The herein-described process of separating metalliferous matter from gangue which consists in agitating a mixture of powdered ore, oil emulsion and water containing an acid and adding particles of material having an affinity for oil to assist in the formation of granules of oil-coated particles and subjecting the mixture to classification to remove the small non-coated particles from the granules.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ARTHUR EDWARD CATTERMOLE.

Witnesses:
HAROLD WADE,
HARRY B. BRIDGE.

1195 [DEFENDANT'S EXHIBIT SPECIFICATION OF LETTERS PATENT NO. 777,274, DATED DECEMBER 13, 1904, ISSUED TO A. E. CATTERMOLE ET AL.]

1196

No. 777,274.

Patented December 13, 1904.

United States Patent Office.

ARTHUR EDWARD CATTERMOLE, HENRY LIVINGSTONE SULMAN, and HUGH FITZALIS KIRKPATRICK-PICARD, of London, England.

Concentration of Minerals from Ores.

Specification Forming Part of Letters Patent No. 777,274, Dated December 13, 1904.

Application Filed March 29, 1904. Serial No. 200,650. (No Specimens.)

To all whom it may concern:

Be it known that we, Arthur Edward Catermole, Henry Livingstone Sulman, and Hugh Fitzalis Kirkpatrick-Picard, subjects of the King of England, residing at London, England, have invented certain new and useful Improvements in the Concentration of Minerals from Ores, of which the following is a specification.

Our process has for its object the separation of minerals from the silicious or earthy matters of ores by means of soaps or similar compounds, and is dependent upon the superior physical attraction exhibited by minerals for fatty or resin acids or for certain other aromatic derivatives (such as cresols, phenols, &c.) which form soluble salts or compounds with alkaline hydrates as compared with earthy or silicious substances.

The process described in this application relates to a process somewhat similar to the process described and claimed in a copending application filed by us of even date with this application and serially numbered 200,649.

In general the soluble compounds we employ are typified by ordinary soaps, from which the fatty or resin acids are liberated by the addition of a suitable mineral acid and which fatty or resin acids are again rendered completely soluble by the addition of an equivalent of caustic alkali.

In carrying out our invention the suitably-crushed ore is suspended in water, and to the mixture an addition of a small quantity of soap solution is made. A small amount of mineral acid is then added, which decomposes the soluble soap or other similar compound by uniting with the alkaline base thereof, thus liberating in a state of chemical subdivision the fatty or resin acid or other compound, such as cresol, &c., in intimate contact with the suspended

ore particles. It is found that the liberated acids, &c., which may even be solid under ordinary conditions, are precipitated and adhere to the sulfureted minerals or to sulfur, graphite, or free metals present in the ore, leaving the gangue or earthy particles preferentially wet by water and free from adhesions of fatty acid and the like. The fatty acid and the like used for the purpose of adhering to the mineral particles is thus produced in situ throughout the suspended ore mass in the most intimate contact or admixture therewith, and the mineral particles become attached to or more or less coated by films of fatty or resin acid. The mixture containing water, fatty or resin acid, metalliferous particles, and gangue is now thoroughly agitated, and the coated metalliferous particles adhere together and form granules or small agglomerate masses, which partly by reason of gravity and partly on account of their bulk, as compared with the individual grains or gangue, may be readily separated in up-currents or by other suitable classification apparatus. This process may conveniently be rendered continuous by feeding ore-pulp, soap solution, and mineral acid continuously into one or more agitating vessels and discharging the products of agitation into an up-current separator, which allows the metalliferous granules to fall to the bottom of the vessel, while the particles of gangue are carried away by an upward stream.

The apparatus employed may be of the type described in Cattermole's United States Patent No. 763,260.

After separation of the coated mineral particles the recovered mineral concentrate is subjected to the action of a suitable amount of caustic or carbonated alkali, whereby the fatty or resin acid, &c., recombines completely with the alkali, forming a readily-soluble soap or alkaline compound. After draining this off and washing with water if necessary, the mineral particles are left clean and free from soap. The resulting solution thus contains all the soap or equivalent compound originally used in a state ready for immediate employment in the separation of mineral from fresh quantities of ore, and the process becomes completely cyclic with regard to the soap employed.

Throughout the operation the same soap or similar compound is used, the constituent whereof may be quite solid under ordinary conditions, the only additions required being small quantities of mineral acid and alkali for the decomposition and recomposition of this agent during the cycle of operations.

1197 & 1198

What we claim as our invention, and desire to secure by Letters Patent, is—

1. The herein-described process of concentrating ores which consists in mixing the ore-pulp with a soap solution and a mineral acid so as to liberate from the soap the organic acid which coats the desired mineral particles but not the gangue, agitating the mixture so as to agglomerate the coated mineral particles into granules and separating the granules from the non-coated gangue.

2. The herein-described process of concentrating ores which consists in mixing the ore-pulp with a soap solution and a mineral acid

which liberates the organic acid from the soap, agitating the mixture so as to agglomerate the coated mineral particles into granules, separating the granules from the non-coated gangue and adding alkali to the granules to reproduce the soluble soap.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

ARTHUR EDWARD CATTERMOLE.
HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK-PICARD.

Witnesses:
FREDERICK READ.
F. B. BUSS.

1199 [DEFENDANT'S EXHIBIT SPECIFICATION OF LETTERS PATENT No. 788,247, DATED APRIL 25, 1905, ISSUED TO A. E. CATTERMOLE ET AL.]

1200 No. 788,247. Patented April 25, 1905.

United States Patent Office.

ARTHUR EDWARD CATTERMOLE, HENRY LIVINGSTONE SULMAN, and HUGH FITZALIS KIRKPATRICK-PICARD, of London, England.

Ore Concentration.

Specification Forming Part of Letters Patent No. 788,247, Dated April 25, 1905.

Application Filed March 29, 1904. Serial No. 200,649.

To all whom it may concern:

Be it known that we, Arthur Edward Cattermole, Henry Livingstone Sulman, and Hugh Fitzalis Kirkpatrick-Picard, subjects of the King of England, residing at London, England, have invented certain new and useful Improvements in Ore Concentration, of which the following is a specification.

Our process has for its object the separation of minerals from the silicious or earthy matters of ores by means of soaps or similar compounds, and is dependent upon the superior physical attraction exhibited by minerals for fatty or resin acids or for certain other aromatic derivatives—such as cresols, phenols, &c.—which form soluble salts or compounds with alkaline hydrates, as compared with earthy or silicious substances.

The process described in this application relates to a process somewhat similar to the process described and claimed in a copending application filed by us of even date with this application and serially numbered 200,650.

In general the soluble compounds we employ are typified by ordinary soaps, from which the fatty or resin acids are liberated by the addition of a suitable mineral acid and which fatty or resin acids are again rendered completely soluble by the addition of an equivalent of caustic alkali.

In carrying out our invention the suitably-crushed ore is suspended in water, and to the mixture an addition of a small quantity of soap solution is made. A small amount of mineral acid is then added, which decomposes the soluble soap or other similar compound by uniting with the alkaline base thereof, thus liberating in a state of chemical subdivision the fatty or resin acid or other compound, such as cresol, &c., in intimate contact with the suspended ore particles. It is found that the liberated acids, &c., which may even be solid under ordinary conditions are precipitated and adhere to the sulfureted minerals or to sulfur, graphite, or free metals present in

the ore, leaving the gangue or earthy particles preferentially wetted by water and free from adhesions of fatty acid and the like. The fatty acid and the like used for the purpose of adhering to the mineral particles is thus produced in situ throughout the suspended ore mass in the most intimate contact or admixture therewith. The mineral particles now attached to or more or less coated or inclosed by films of fatty or resin acids and the like are capable of being separated from the gangue or earthy particles by various methods dependent upon this altered physical condition. For example, the coated mineral particles may be removed by generating gaseous bubbles in the mixture which preferentially attach themselves to the fatty or similar acid-coated particles and raise them to the surface of the pulp, whence they may be removed by skimming or the like. If the ore contains a carbonate, any small excess of the acid used to decompose the soap or similar alkaline compound will also liberate bubbles of carbonic acid, which will attach themselves to the fatty acid-coated mineral particles and float them to the surface, or a suitable carbonate (or other substance capable of liberating a gas on the addition of a suitable acid, such as an easily decomposable sulfid, &c.) may be initially added to the ore mass for such purpose, or the mineral particles may be caused to adhere to metallic or other suitable surfaces coated with similar fatty acids, or, finally, the coated mineral particles may be caused to adhere to wood, sawdust, or other suitable material lighter than water coated with similar fatty acids, &c., which can then be removed by flotation, in each case leaving the mineral-free gangue particles capable of rejection. After separation of the coated mineral particles by any of the methods before mentioned the recovered mineral concentrate is subjected to the action of a suitable amount of caustic or carbonated alkali, whereby the fatty or resin acid, &c., recombines completely with the alkali, forming a readily soluble soap or alkaline compound. After draining this off, and washing with water, if necessary, the mineral particles are left clean and free from soap.

1201 & 1202

The resulting solution thus contains all the soap or equivalent compound originally used in a state ready for immediate employment in the separation of mineral from fresh quantities of ore, and the process becomes completely cyclic with regard to the soap employed.

Throughout the operation the same soap or similar compound is used, the constituent whereof may be quite solid under ordinary conditions, the only additions required being small quantities of mineral acid and alkali for the decomposition and recomposition of this agent during the cycle of operations.

What we claim as our invention, and desire to secure by Letters Patent, is—

1. The herein-described process of concentrating ores which consists in mixing a freely-flowing ore pulp with a soap solution and a mineral acid so as to liberate the organic acid from the soap throughout the suspended ore mass in intimate contact therewith, whereby the organic acid coats the desired mineral particles and not the

gangue, and thereafter separating the coated mineral matter from the non-coated gangue.

2. The herein-described process of concentrating ores which consists in mixing the ore pulp with a soap solution and a mineral acid which liberates the organic acid from the soap, separating the coated mineral matter from the non-coated gangue and adding alkali to the coated mineral matter to reproduce the soluble soap.

3. The herein-described process of concentrating ores which consists in mixing a freely-flowing ore pulp with a soap solution and a mineral acid so as to liberate the organic acid from the soap throughout the suspended ore mass in intimate contact therewith, bringing the liquor into intimate contact with a gas which will adhere to the coated particles and separating out the coated mineral matter which floats.

4. The herein-described process of concentrating ores which consists in mixing the ore pulp with a soap solution and a mineral acid which liberates the organic acid from the soap, bringing the liquor into intimate contact with a gas, separating out the coated mineral matter which floats and adding thereto an alkali which reproduces the soluble soap.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

ARTHUR EDWARD CATTERMOLE.
HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK-PICARD.

Witnesses:
T. B. BUSS.
FREDERICK READ.

No. 793,808. PATENTED JULY 4, 1905.

H. L. SULMAN & H. F. KIRKPATRICK-PICARD.

ORE CONCENTRATION.

APPLICATION FILED OCT. 5, 1903.

3 SHEETS—SHEET 1

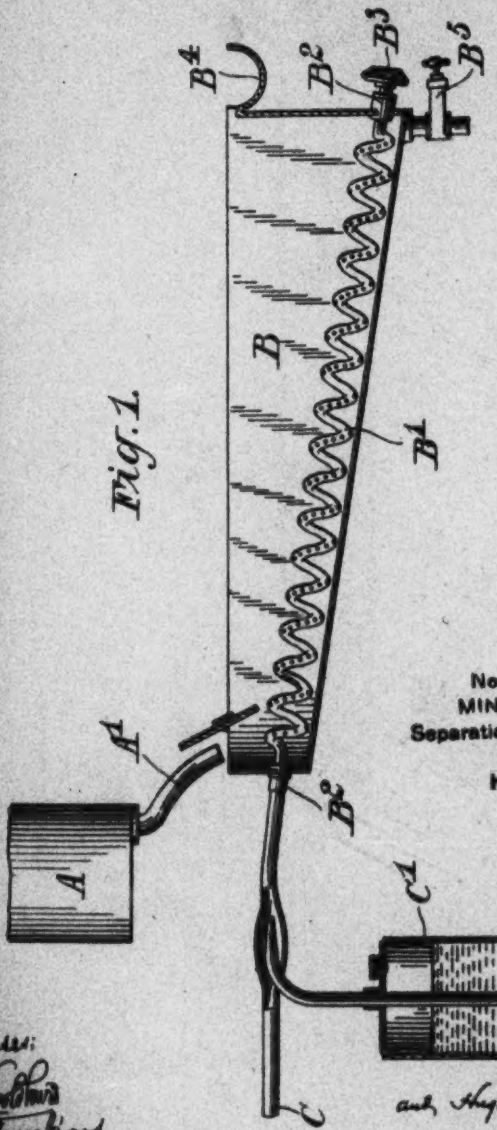


Fig. 1.

No 259
MINERALS
Separation, Ltd. et al. } Page 1704
v.
HYDE.

Witnesses:
[illegible]
J. M. Maynhoop.

Inventors
Henry L. Sulman
and Hugh F. Kirkpatrick-Picard
By Knight Bros
Attys

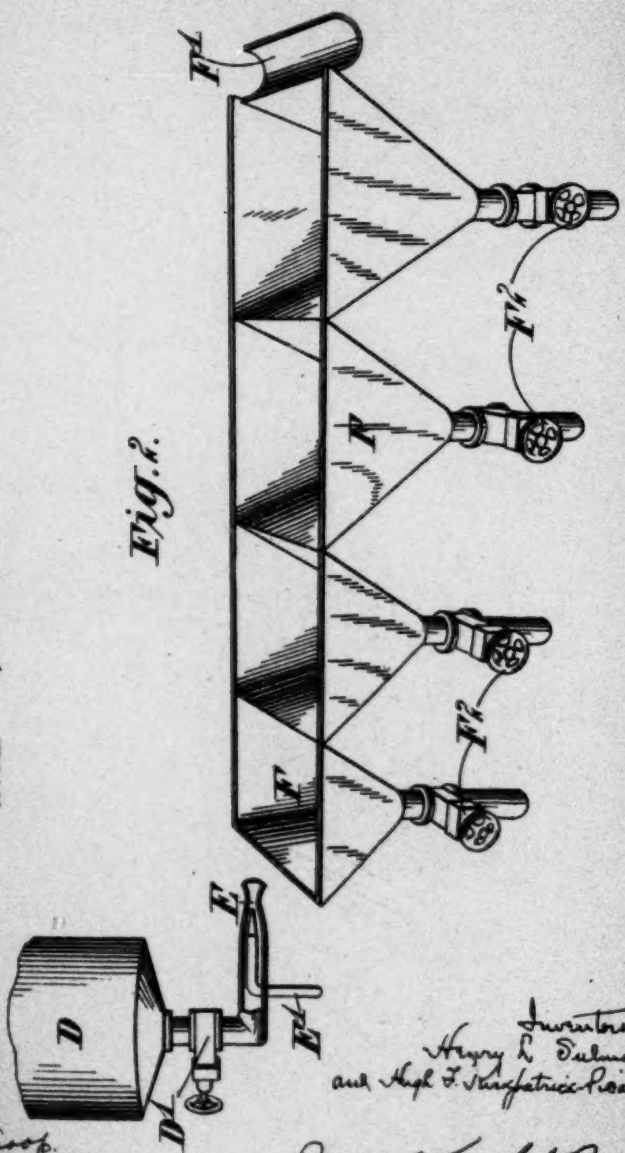
No. 793,808. PATENTED JULY 4, 1905. 1205

H. L. SULMAN & H. F. KIRKPATRICK-PICARD.

ORE CONCENTRATION.

APPLICATION FILED OCT. 5, 1903.

3 SHEETS—SHEET 2.

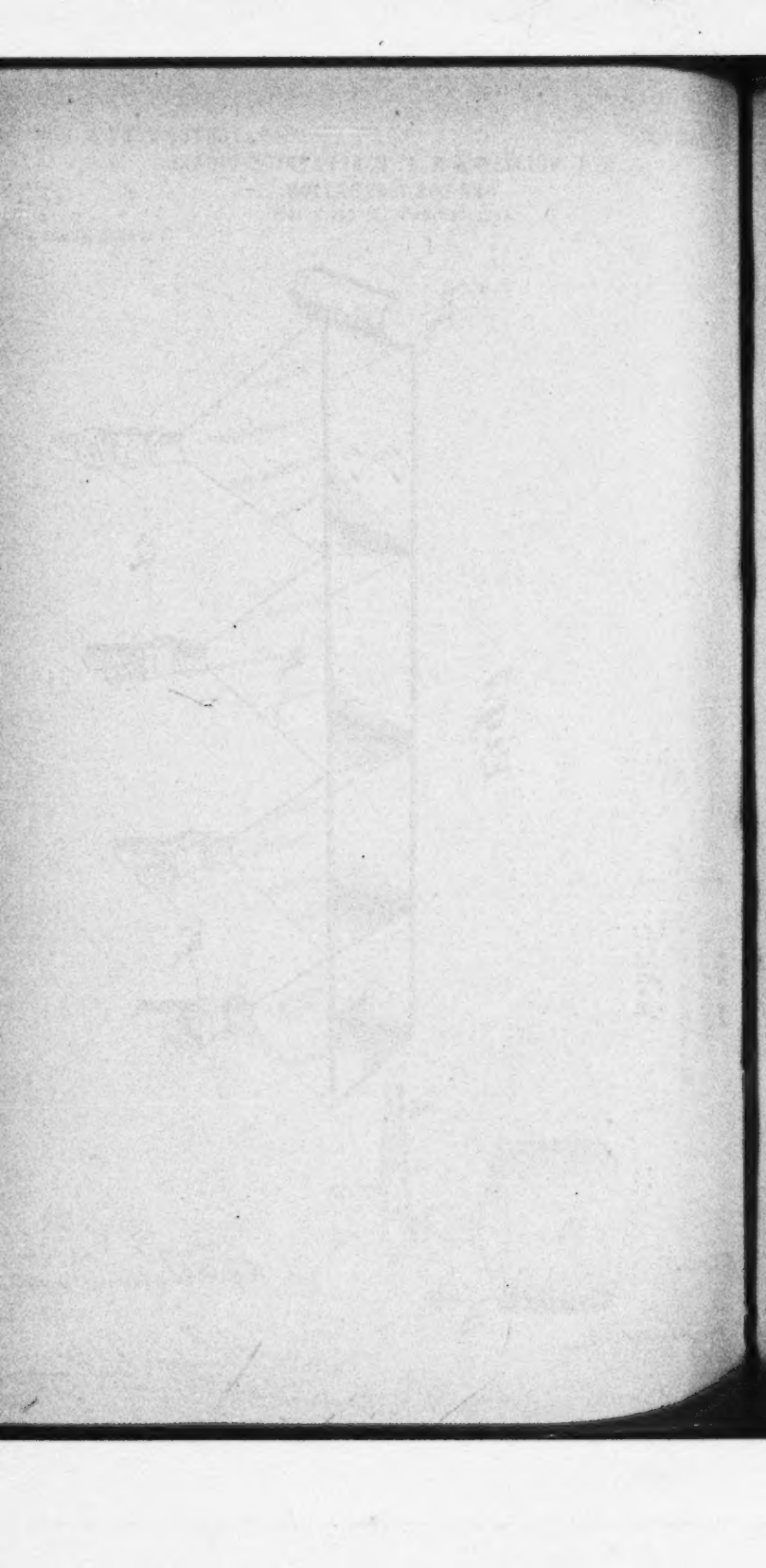


No. 259
MINERALS
Separation, Ltd. et. al.
v.
HYDE.
Page 1205

Witnesses:
Harold Hird
J. M. Stynhoop.

Inventors:
Henry L. Sulman
and Hugh F. Kirkpatrick-Picard.

By Knight Bros
Attys



No. 793,808. PATENTED JULY 4, 1905 1206

H. L. SULMAN & H. F. KIRKPATRICK-PICARD.

ORE CONCENTRATION.

APPLICATION FILED OCT. 5, 1903.

3 SHEETS—SHEET 3.

Fig. 3.

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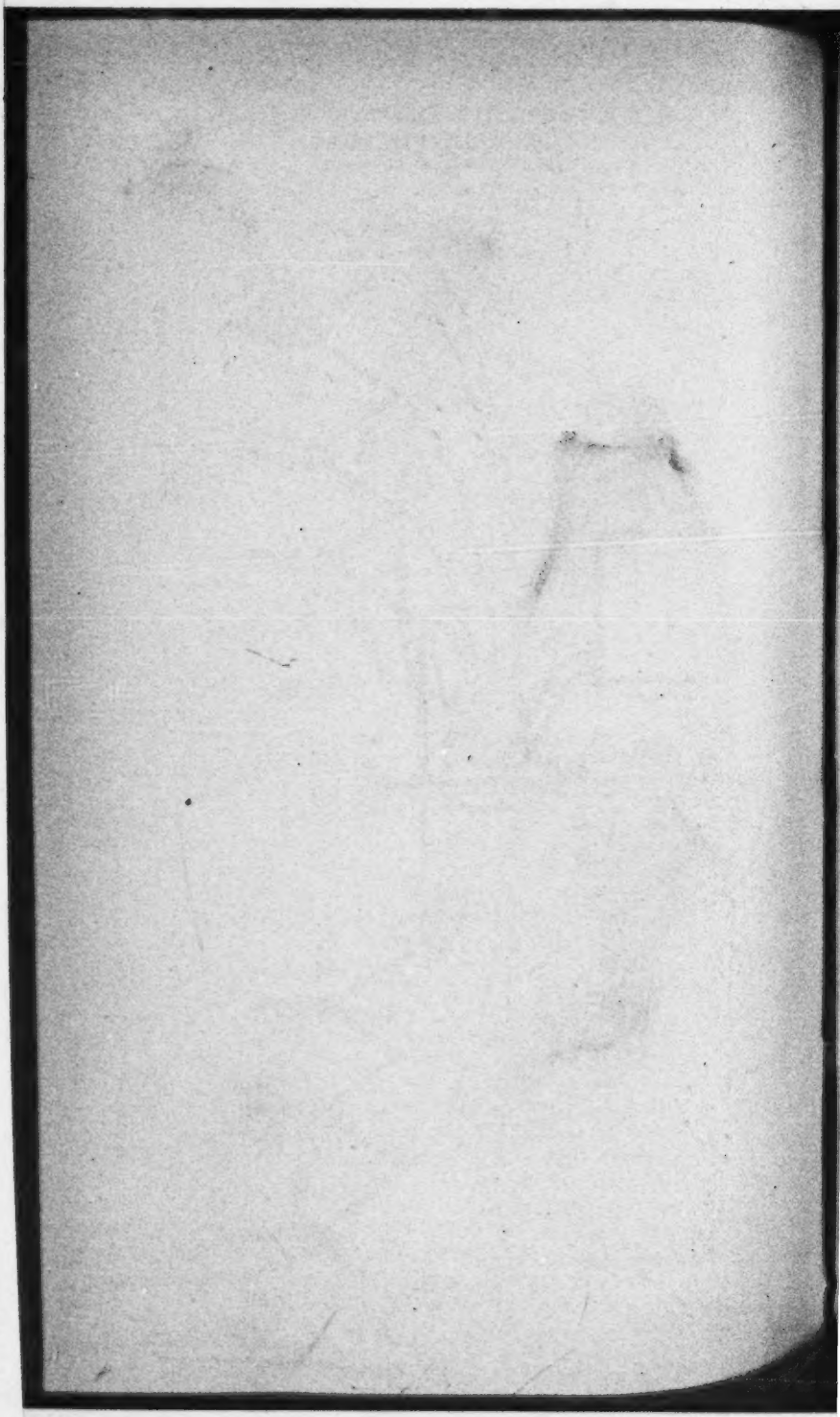
MINERALS
Separation, Ltd. et al. } Page 1206
v.
HYDE.

WITNESSES:

INVENTORS

BY

Attorneys



1203 [DEFENDANT'S EXHIBIT DRAWINGS AND SPECIFICATION OF LETTERS PATENT NO. 793,808, PATENTED JULY 4, 1905, ISSUED TO H. L. SULMAN ET AL.]

(Here follow diagrams marked pp. 1204, 1205 and 1206.)

1207 No. 793,808. Patented July 4, 1905.

United States Patent Office.

HENRY LIVINGSTONE SULMAN and HUGH FITZALIS KIRKPATRICK-PICARD, of London, England.

Ore Concentration.

Specification Forming Part of Letters Patent No. 793,808, Dated July 4, 1905.

Application Filed October 5, 1903. Serial No. 175,871.

To all whom it may concern:

Be it known that we, Henry Livingstone Sulman and Hugh Fitzalis Kirkpatrick-Picard, subjects of the King of England, residing at London, England, have invented certain new and useful Improvements in or Relating to Ore Concentration, of which the following is a specification.

The present invention relates to the concentration of ores by separation of the metalliferous constituents and graphite, carbon, sulfur, and the like from the gangue by means of oils, grease, tar, or any similar substance which has a preferential affinity for metalliferous matter over gangue.

According to this invention we utilize the power which is possessed by films or bubbles of air or other gas of attaching themselves to solid particles moistened by oil or the like.

According to one method of carrying out our invention suitably-crushed ore is suspended in water. To this suspension a proportion of oil, grease, or tar (hereinafter referred to as "oil") is added and duly mixed with the mass by any suitable means in quantity insufficient to raise the oiled mineral by virtue of the flotation power of the oil alone. A suitable gas is now generated in or introduced into the mixture, such as air, carbonic-acid gas, sulfureted hydrogen, or the like. For example, bicarbonates or carbonates, either soluble or insoluble in water (preferably the latter) or easily-decomposable sulfids and the like may be used with acid solution. In such cases, if desired, the addition of acid may be made to the mix-

ture after the addition of the gas-producing reagent. In the case of solutions containing free alkali the addition of acid sufficient to neutralize this must be made before the gas is produced. If desirable, gaseous bubbles may be produced by electrolytic methods or by means of various other known reactions.

According to another method of carrying out this invention the oil is not added alone; but the pulp is submitted to the action of a current of air or other gas bubbles, the air or other gas being first suitably charged either with the vapor of a volatile oil, such as petroleum of low boiling-point, or with the spray of any other suitable volatile or non-volatile or fixed oil or the like. The oil may be sprayed or reduced to a state of such fine division that minute globules of the same can remain temporarily suspended in an air or other gas current by the use of any suitable spraying or atomizing device and the air-current introduced into the ore-pulp, preferably at the bottom, by means of a pipe or pipes provided with suitable perforations or by other suitable contrivance. The minute oil globules or the condensed vapors or volatile oils attach themselves to the metalliferous particles in preference to the gangue.

The oiled metalliferous particles resulting from either of the processes above described have the power of attaching to themselves with a greater comparative strength than the gangue particles the films or bubbles of gas which exist in the mass and are thus raised to the surface of the liquor by gaseous flotation. They can then be removed by skimming or other suitable means. The gangue particles unwetted by oil or grease are not floated up with the oiled mineral particles, and thus in the main remain at the bottom of the vessel containing the mixture. The oil can then be removed from the oiled mineral by any suitable known means.

In the case in which oil-spray is used the temperature of the mass of pulp may be varied to secure the best results with spray of oils of varying viscosity. Instead of suspending the oil-spray in an air-supply system suitably-devised atomizing-jets operated by air or a jet of steam and air may be introduced directly into the pulp. The gas used may be other than air, such as carbonic acid, steam, or mixtures of these. We have also found that a particle of metalliferous mineral if coated with a minute film of oil, grease, or the like then exposed to air will not readily sink in water. It is therefore unnecessary in some instances to employ gaseous bubbles to effect flotation. For example, according to an alternative method for effecting the separation of metalliferous matter from gangue the metalliferous ore-pulp is intimately mixed in any suit-
1208 able manner with a small proportion of oil and then sprayed in as finely divided a state as necessary through air by means of jets, revolving disks, or otherwise, and the sprayed product is then allowed to fall upon the surface of water. The gangue particles wetted only with water at once sink, while the metalliferous particles coated with a thin film of oil and after exposure to air float on the surface of the water and may be removed by skimming or other suitable means. Before bringing the pulp into the necessary

contact with air it will be obvious that the bulk of the water may first be removed by subsidence or any other suitable means.

In the accompanying drawings, Figure 1 is a diagram in longitudinal section of an apparatus suitable for carrying out this process. Fig. 2 is a diagram in perspective, partly in section, of another form of suitable apparatus; and Fig. 3 is a diagram in perspective, partly in section, of an alternative form of apparatus.

Referring to Fig. 1, A is a tank for pulp, which delivers through a pipe A′ to a concentrating-tank B, the bottom of which slopes downward from the inlet. The tank B is provided at the bottom with a coiled pipe B′, suitably perforated, supported in bearings B^2, and arranged to be rotated by means of a spur-wheel B^3 or the like. Air is forced into this pipe B′ through a pipe C, and oil is simultaneously introduced into the pipe C from a carbureter or the like C′. At the end of the tank B farthest from the pulp-inlet a launder B^4 is placed to receive the discharge of floating material, and an outlet-tap B^5 is provided at the lowest point of the tank.

Referring to Fig. 2, D is a tank in which pulp and oil are mixed, and the mixture passes through an outlet-tap D′ to an ejector E, through which air under pressure is passed by the pipe E′. The spray of pulp, oil, and air falls into a tank F, filled with water and consisting of a series of communicating pointed boxes, which increase in depth from the inlet end. A launder F′ is provided at the outlet end of the tank, and outlet-taps F^2 are placed at the lowest points of the boxes.

Referring to Fig. 3, G is a tank in which pulp and oil are mixed. H is a circular disk attached to a vertical spindle H′, supported in bearings H^2 and arranged to be rotated through a driving-pulley H^3 or the like. Surrounding the spindle is a cylindrical collar J, connected with the tank G by a pipe J′, so that the pulp and oil are fed through the collar to the rotating disk. Surrounding the disk is a series of annular pointed troughs K, communicating with one another and increasing in depth toward the outside and filled with water. A launder K′ is provided at the periphery of the outside trough to receive the discharged floating material, and outlet-taps K^2 are placed at the lowest points of the troughs.

This process has been described as applied to ore concentration by oil; but it is to be understood that it is equally applicable to concentration by the use of any other substance which has an affinity for metalliferous matter.

We claim—

1. The herein-described process of concentrating ores which consist in bringing the pulp into intimate contact with "oil" in the form of spray and with a gas and thereafter separating the metalliferous constituents from the gangue.

2. The herein-described process of concentrating ores which consists in bringing the pulp into intimate contact with "oil" disseminating the mixture through air and thereafter separating the metalliferous constituents from the gangue in water.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK-PICARD.

Witnesses:

CLAUDE C. R. McKENZIE,
WALTER J. SKERTEN.

1209 [DEFENDANT'S EXHIBIT SPECIFICATION OF LETTERS PATENT No. 807,501, PATENTED DECEMBER 18, 1905, ISSUED TO ALFRED SCHWARZ, ETC.]

1210 United States Patent Office.

ALFRED SCHWARZ, of New York, N. Y., Assignor to SCHWARZ ORE TREATING COMPANY, of Phœnix, Arizona Territory, a Corporation of Arizona Territory.

Process of Concentrating Ores

No. 807,501. Specification of Letters Patent. Patented Dec. 19, 1905.

Application Filed April 19, 1905. Serial No. 256,487.

To all whom it may concern:

Be it known that I, Alfred Schwarz, a subject of the Emporer of Germany, and a resident of the borough of Manhattan, city, county, and State of New York, have invented certain new and useful Improvements in Processes of Concentrating Ores, of which the following is a specification.

In the concentration of ores by the employment of hydrocarbons as adhesive agents it has been observed that sulfids yield better results than oxids, carbonates, and chlorids. In fact, so far as known to me, a practical application of such process before my invention relating to this art has been largely, if not wholly, confined to sulfid ores.

The object of the present invention is to extend the application of hydrocarbon concentrating processes to ores heretofore considered unworkable by first converting such ores into sulfids, preferably by a wet method, to thereby preserve the mass of ore in its crushed condition and suitable for treatments according to known methods.

In carrying out the present invention I proceed by preparing a soluble sulfid in any well-known manner—for example, by dissolving sulfur in an aqueous solution of potassium or sodium hydrate, the sulfur being added in sufficient quantity to give the desired reaction. The pulverized ore containing the mineral in the form of oxide, carbonate, or chlorid is then mixed in a suitable vessel with the sulfid solution, the mass being either cold or heated by suitable means and the vessel provided with an agitator to effect a thorough and intimate mixture. During this operation the oxid, carbonate, or chlorid is converted into a sulfid by the action of the potassium or sodium sulfid, a form which is capable of subsequent practical treatment with hydrocorbons for the separation of the values from the earthy or rocky constituents of the ore. As the action of the hydrocarbon on the metallic constituents of the ore is a surface action, it is unnecessary to proceed so far as to convert the entire mass of the particles of oxid, carbonate, or chlorid into a sulfid,

it being sufficient if the surface of the particles is so converted, as thereby there is presented all that is necessary for the desired action of the hydrocarbon.

After the initial conversion, as above described, the ore may be concentrated by any suitable treatment with a hydrocarbon, and for such purpose I may use a hydrocarbon which is normally liquid or one which is solid at normal temperatures, or the latter in admixture with the former, as described in my applications Serial Nos. 210,137, 210,138, 225,370, and 231,395, and United States Patent No. 771,277. Of hydrocarbons which are solid at normal temperatures and required to be melted there may be used paraffin or ozocerite, or a resinous hydrocarbon, such as resin, pitch, or asphaltum. Of normally liquid hydrocarbons there may be used any suitable vegetable, animal, or mineral oil. These hydrocarbons may be used singly or in combination of two or more, it being understood that the constitution of the adhesive agent will depend upon the character of the ore to be treated, varying as the ore varies.

Ore either in a dry or wet condition is mixed in any suitable vessel having an agitator with the hydrocarbon, sufficient quantity being added to effect the desired separation. If the hydrocarbon is one which is solid at normal temperatures, it is first melted and then stirred in with the ore, the mixture being effected by any suitable mechanical means and, if desired, air, steam, or gas may be injected into the mass either alone or to assist the mechanical agitation. The injection of such gaseous agent results in the hydrocarbon taking up an appreciable quantity of air or gas, giving a certain sponginess which increases its floating power.

As a specific example of my invention I have used as an adhesive agent a mixture of paraffin and resin, heat being employed if necessary to maintain this compound in a melted condition after it has been mixed with the ore.

After an intimate mixture with all parts of the ore has been effected the mass is subjected to the action of water heated to any desired temperature, even as high as the boiling-point, whereby the earthy or rocky constituents are liberated and washed out and settle in the bottom of the vessel. The metallic constituents of the ore having been united with the adhesive agent may be skimmed or screened off and run to a centrifugal drier for the separation or recovery of the concentrates from the adhesive agent.

1211 & 1212

Instead of subjecting the mass to the action of heated or boiling water cold water, preferably under pressure, may be injected into the mass, the effect of which is to solidify or granulate the adhesive agent, which with the entrapped metallic constituents may be floated or screened off, while the tailings being saturated with water will be precipitated more or less completely to the bottom of the vessel. By subjecting the mass to heat in a suitable vessel the adhesive agent is melted and the concentrates may be separated and recovered therefrom by a centrifugal drier, filter-press, or other means. The mass of ore and adhesive agent may first be treated with heated or boiling water and subsequently treated with cold water. Also during

the treatment with water, which may be made acid or alkaline, if desired, the mass may be agitated mechanically or by the injection of air, steam, or gas.

The concentrates, if necessary, may be washed with a solution of potassium or sodium hydrate to remove any remaining portions of the adhesive agent.

While I have described in giving a specific method of procedure the use of a mixture of paraffin and resin, I may use either one of these singly, the successive steps of the operation being the same, or I may use singly a normally liquid hydrocarbon, following the same method of operation except in such case there will of course be no solidification or granulation of the hydrocarbon. When using a normally liquid hydrocarbon, the mass may be treated either with cold or heated water to effect the separation of the adhesive agent with the metallic constituents of the ore from the tailings.

The essential feature of the present invention is the conversion of an ore of the character above specified into a sulfid to adapt it for treatment by a hydrocarbon, the particular method of concentrating by the employment of a hydrocarbon being varied according to known methods as may be desired or suitable to the particular ore, and while I have given specific examples I do not wish to be wholly restricted thereto.

In carrying out the conversion above described I use an excess of sulfur above the theoretical quantity necessary to effect the change of oxid, carbonate, or chlorid to sulfid.

What I claim, and desire to secure by Letters Patent, is—

1. The method of treating ores which consists in subjecting a non-sulfid ore to the action of a soluble sulfid to convert the mineral into a sulfid, then treating the mass with a hydrocarbon and finally separating the hydrocarbon with the entrapped metallic constituents of the ore from the tailings.

2. The method of treating an ore containing non-sulfid mineral by subjecting the same to the action of an alkaline sulfid to convert the mineral into a sulfid, then treating the mass with a hydrocarbon and finally separating the hydrocarbon with the entrapped metallic constituents of the ore from the tailings.

3. The method of treating an ore containing non-sulfid mineral by subjecting the same to the action of an aqueous solution of potassium or sodium sulfid to convert the mineral into a sulfid, then treating the mass with a hydrocarbon and finally separating said hydrocarbon with the entrapped metallic constituents of the ore from the tailings.

4. The method of treating an ore containing non-sulfid mineral by subjecting the same to the action of a soluble sulfid, then treating the resulting metallic sulfid with a melted hydrocarbon which is solid at normal temperatures and finally separating said hydrocarbon with the entrapped metallic constituents form the tailings.

5. The method of treating an ore containing non-sulfid mineral by subjecting the same to the action of a soluble sulfid, then treating the resulting metallic sulfid with a compound of melted paraffin

and resin, then separating said compound with the entrapped metallic constituents from the tailings.

In testimony whereof I have hereunto signed my name in the presence of two subscribing witnesses.

ALFRED SCHWARZ.

Witnesses:

E. F. PORTER,
ALEXANDER RODMAN.

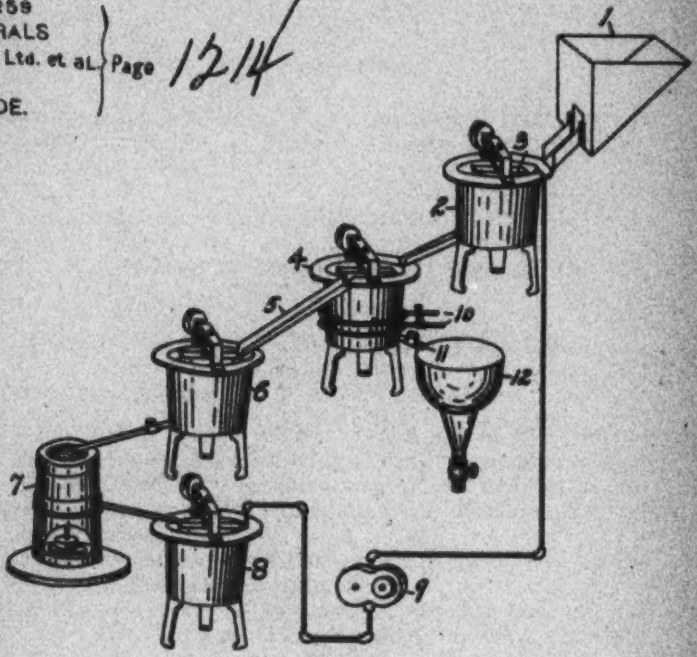
No. 807,503. PATENTED DEC. 19, 1905.

A. SCHWARZ.

PROCESS OF CONCENTRATING ORES.

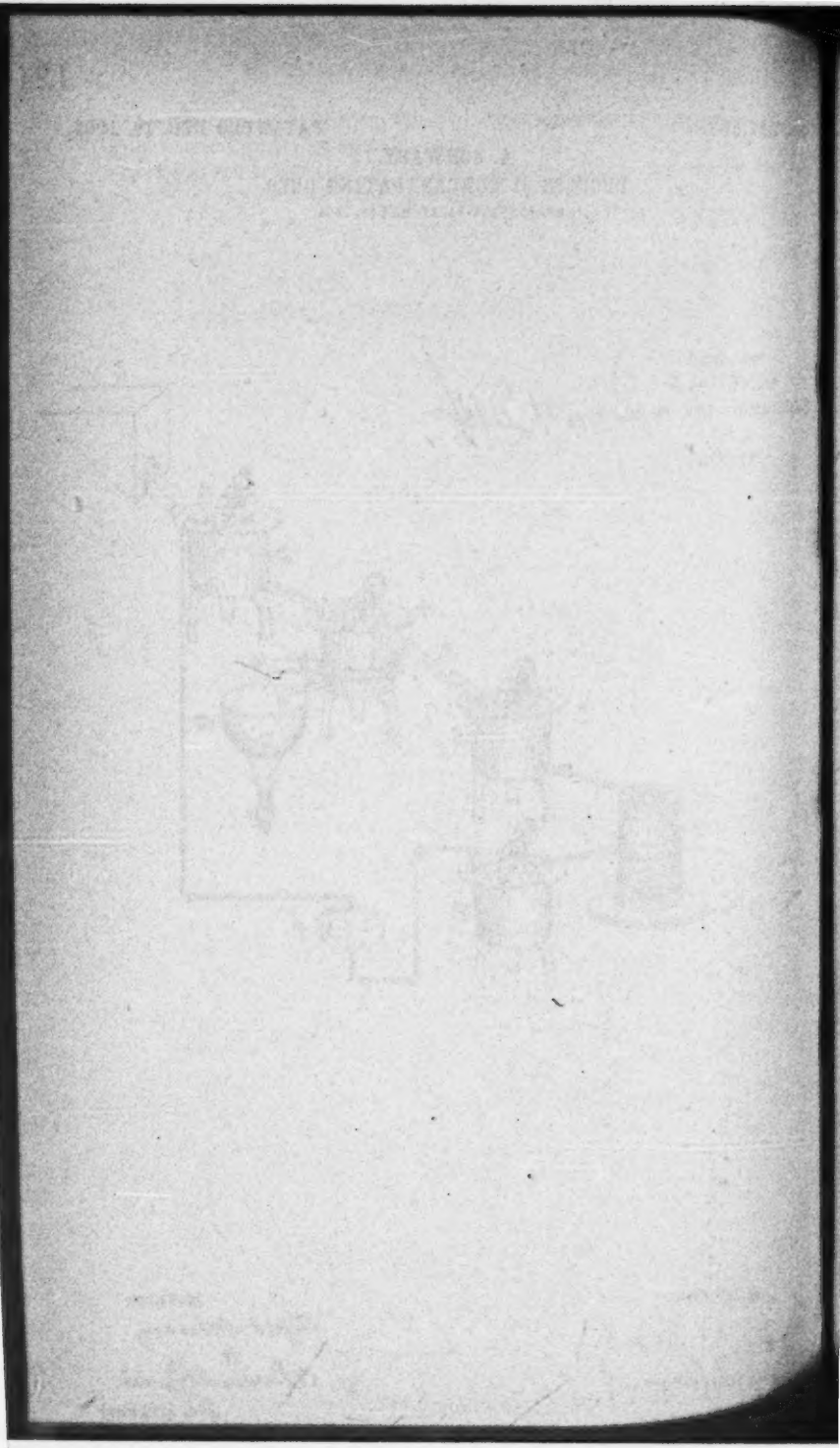
APPLICATION FILED MAY 27, 1904.

No 259
MINERALS
Separation, Ltd. et al
v.
HYDE.
Page 1214



WITNESSES:
Grace D. Healey.
Harry Schwarz.

INVENTOR
Alfred Schwarz
BY
Charles D. Jones.
ATTORNEY



1213 [DEFENDANT'S EXHIBIT DRAWING AND SPECIFICATION OF LETTERS PATENT No. 807,503, PATENTED DECEMBER 19, 1905, ISSUED TO A. SCHWARZ.]

(Here follows diagram marked p. 1214.)

1215 United States Patent Office.

ALFRED SCHWARZ, of New York, N. Y., Assignor to the SCHWARZ ORE TREATING COMPANY, of Phœnix, Arizona Territory, a Corporation of Arizona Territory.

Process of Concentrating Ores.

No. 807,503. Specification of Letters Patent. Patented Dec. 19, 1905.

Application Filed May 27, 1904. Serial No. 210,138.

To all whom it may concern:

Be it known that I, Alfred Schwarz, a subject of the German Emperor, and a resident of the borough of Manhattan, city, county, and State of New York, have invented certain new and useful Improvements in Processes of Concentrating Ores, of which the following is a specification.

My invention has for its object the concentration of ores by the selective action of a hydrocarbon compound.

Heretofore the separation of the values in ores has been effected by mixing the pulverized ore with a product resulting from the distillation of petroleum, the ore having been previously mixed with sufficient water to form a freely-flowing pulp. The oil in such method exercises the property of attaching itself to and buoying up the metallic constituents of the ore that are suspended in the pulp; but it has little or no effect upon the earthy constituents. I have found that the efficiency of the selective action of oils generally, either mineral, vegetable, or animal, is increased by the addition thereto of a fatty matter which is solid at normal temperatures, as paraffin, stearin, or palmitin.

In carrying out my invention I proceed as follows: The ore is first crushed and screened to a convenient size for working and is then thoroughly and intimately mixed with the selective material, which in this instance is a compound of a mineral, vegetable, or animal oil and a fatty matter of the character above specified, such mixture being solid at normal temperatures. Such material may

be readily prepared by dissolving the fatty matter in the oil medium, heat being employed to melt the fatty matter, if necessary, and to maintain the compound in a liquid condition during its incorporation with the pulverized ore. As a specific example of a selective material I prefer crude petroleum or any of its products, to which is added about nine to ten per cent., by weight, of paraffin, such proportion having been found to give good results with a copper-sulfid ore.

Any suitable apparatus may be employed to effect the mixture of the ore and selective material, all that is essential being a vessel provided with agitating-blades. In such vessel the ore is mixed with sufficient of the selective material to make a thick pasty mass, the agitation being continued long enough to bring the selective material into intimate contact with all portions of the ore. The vessel may be steam-jacketed or otherwise suitably heated if found necessary to maintain the selective material in a liquid condition. After a complete incorporation of the selective material with the ore water, preferably under pressure, is injected into the mass by suitably-arranged pipes and agitation continued until the water is distributed throughout the mass. The mass is then allowed to subside, when the selective material, with the entrapped metallic constituents of the ore, will rise to the top and may be removed in any suitable manner, as by floating over the top of the vessel. The values may be separated from the selective material in any suitable or well-known manner—as, for example, by a centrifugal drum or filter-press. The tailings, being unaffected by the selective material, will remain in the water and settle to the bottom of the vessel, from which they may be drawn off and, if necessary, subjected to further treatment for the recovery of any values they may contain.

In the concentration of ores by the selective action of the compound above described the action is facilitated and better results secured by the injection of a gaseous fluid—such as air, steam, or gas as carbon-dioxid gas—into the mass. This may be done by suitably-arranged pipes leading into the bottom or sides of the vessel, the effect of such use of air, steam, or gas being to break up and subdivide the mass in a complete and thorough manner. Furthermore, it results in the selective material taking up an appreciable quantity of air or gas, giving a certain amount of sponginess, which increases its floating power. After the admission of water, which may be done by suitably-arranged pipes, the admission of air, steam, or gas may be continued to assist in distributing the water throughout the mass and to effect a thorough separation and washing out of the tailings.

In referring to paraffin as a "fatty matter" it is to be understood that I do so in a popular and not a chemical sense. It is also to be understood that the proportions of the ingredients of the selective material may be varied to suit the particular ore treated.

1216 The accompanying drawing shows in perspective one arrangement of apparatus by which the process may be carried out.

1 designates a bin or hopper from which the pulverized ore is discharged into a vessel 2, which is preferably steam-jacketed and provided with an agitator 3. In this vessel the ore and selective agent are intimately mixed, and from said vessel the mass is discharged into a vessel 4, provided with an agitator in which it is treated with water slightly acidulated, if desired, to effect the separation of the selective agent, with the entrapped metallic constituents, from the tailings. If cold water is employed, the selective agent will be solidified and rising to the top is conducted by a trough 5 to a remelting and storage vessel 6. If heated or boiling water is employed in the vessel 4, the selective agent will be maintained in its liquid condition and as it rises with the entrapped metallic constituents is run by the trough 5 into the storage vessel 6 and from the latter to a centrifugal-drum 7 for the separation of the values from said agent. The recovered agent is collected in a storage vessel 8, from which it may be raised to the mixing vessel 2 by a pump 9. The separating vessel 4 is provided with suitable pipes 10 for the admission of air, steam, or gas and with a pipe 11 by which the tailings may be discharged into a vessel 12. After removal of the values from the separator 7 they may be subjected to any suitable treatment.

What I claim, and desire to secure by Letters Patent, is—

1. The process of concentrating ores consisting in mixing with the pulverized ore a selective agent consisting of a mixture of a liquid hydrocarbon and a normally solid fatty matter which mixture is solid at normal temperatures, separating said agent with its entrapped values from the tailings, and finally recovering the values from the selective agent.

2. The process of concentrating ores consisting in mixing with the pulverized ore a selective agent consisting of a mixture of a liquid hydrocarbon and a normally solid fatty matter which mixture is solid at normal temperatures, treating the mass with water to separate said agent with its entrapped values from the tailings, and finally recovering the values from the selective agent.

3. The process of concentrating ores consisting in mixing with the pulverized ore a selective agent consisting of a mixture of a liquid hydrocarbon and a normally solid fatty matter which mixture is solid at normal temperatures, treating the mass with cold water to separate said agent with its entrapped values from the tailings, and finally recovering the values from the selective agent.

4. The method of concentrating ores consisting in mixing with the pulverized ore a selective agent consisting of a mixture of a liquid hydrocarbon and a normally solid fatty matter which mixture is solid at normal temperatures and subjecting the mass to the action of a gaseous fluid, separating the selective agent with its entrapped values from the tailings, and finally recovering the values from the selective agent.

5. The process of concentrating ores consisting in mixing with the pulverized ore a selective agent consisting of a mixture of a liquid hydrocarbon and paraffin which mixture is solid at normal temperatures, separating said agent with its entrapped values from

the tailings, and finally recovering the values from the selective agent.

6. The process of concentrating ores consisting in mixing with the pulverized ore a selective agent consisting of a mixture of a liquid hydrocarbon and paraffin which mixture is solid at normal temperatures, treating the mass with water to separate said agent with its entrapped values from the tailings, and finally recovering the values from the selective agent.

In testimony whereof I have hereunto signed my name in the presence of two subscribing witnesses.

ALFRED SCHWARZ.

Witnesses:
E. F. PORTER,
CHARLES S. JONES.

No. 809,959. PATENTED JAN. 16, 1906.

E. B. KIRBY.

PROCESS OF SEPARATING MINERALS.

APPLICATION FILED DEC. 14, 1905.

2 SHEETS—SHEET 1.

Fig. 1.

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Witnesses.
E. B. Gilchrist
J. B. Hill

Inventor
Edmund B. Kirby,
By his Attorneys,
Thurston & Bates.

No. 809,959. PATENTED JAN. 16, 1906.

E. B. KIRBY.

PROCESS OF SEPARATING MINERALS.

APPLICATION FILED DEC. 14, 1903.

2 SHEETS—SHEET 1.

No. 259
...ERALS
Separation, Ltd. et al. } Page 1214
v.
HYDE.

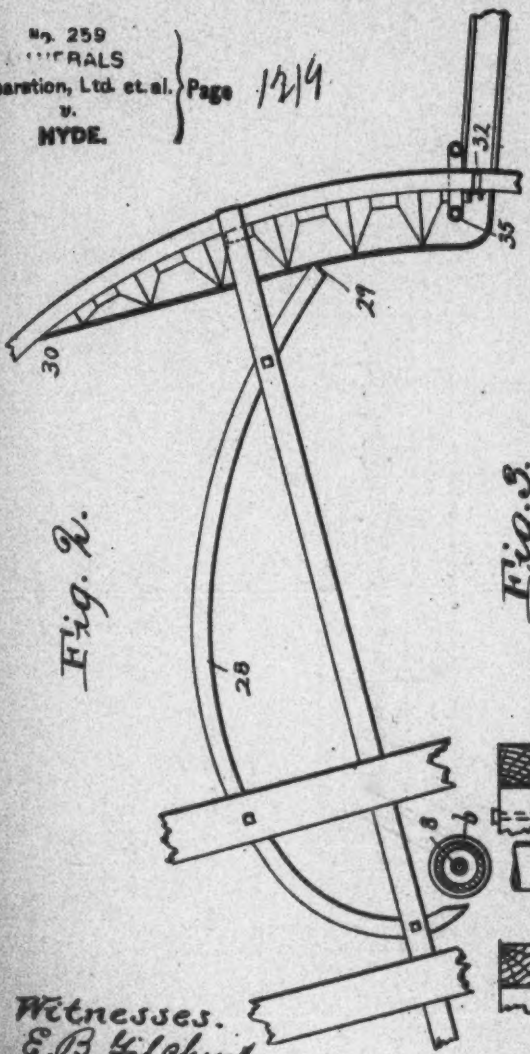

Fig. 2.

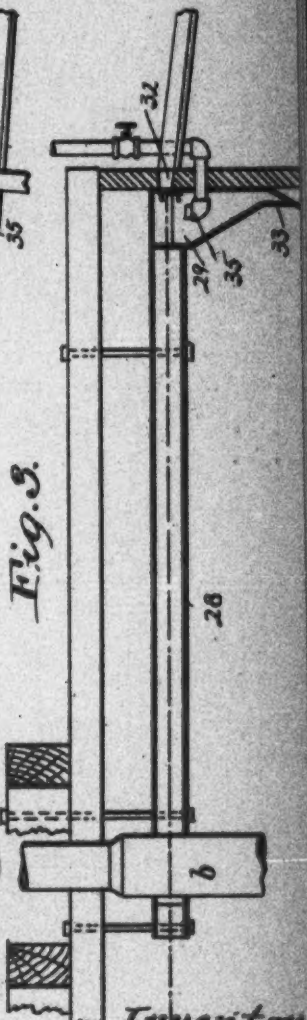

Fig. 3.

Witnesses.
E. B. Kilchurst
J. B. Hull

Inventor
Edmund B. Kirby,
By his Attorneys,
Thurston & Bartol

No. 809,959. PATENTED JAN. 16, 1906.

E. B. KIRBY.

PROCESS OF SEPARATING MINERALS.

APPLICATION FILED DEC. 14, 1901.

3 SHEETS—SHEET 3.

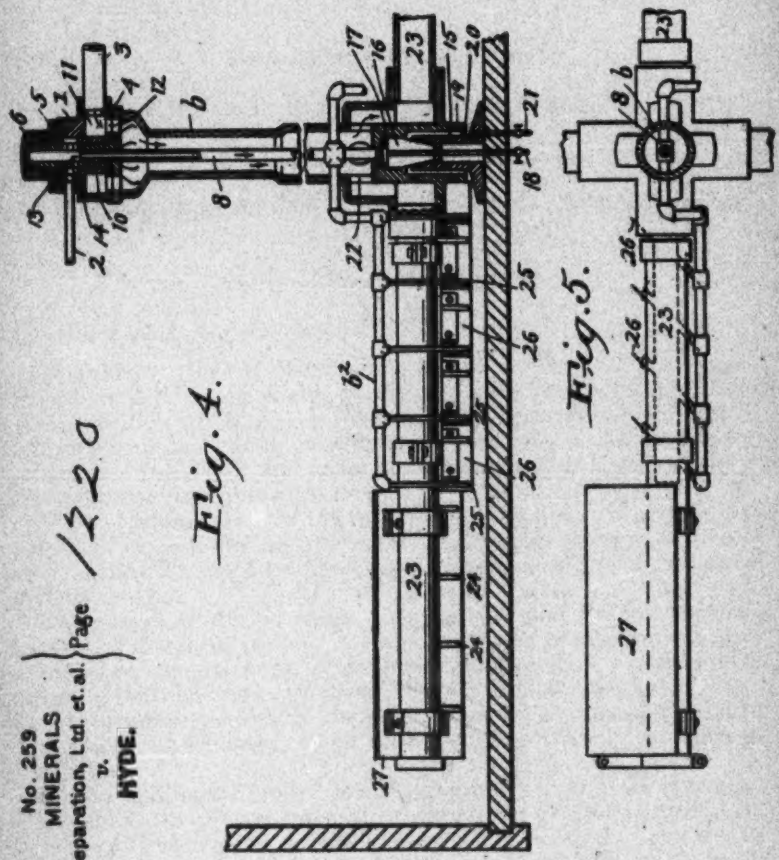

Fig. 4.

Fig. 5.

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Witnesses.
E. B. Gilchrist
J. B. Hull

Inventor:
Edmund B. Kirby,
By his Attorneys,
Hunt & Betts

1217 [DEFENDANT'S EXHIBIT DRAWINGS AND SPECIFICATION OF LETTERS PATENT No. 809,959, PATENTED JANUARY 16, 1906, ISSUED TO E. B. KIRBY.]

(Here follow diagrams marked 1218, 1219 and 1220.)

1221 United States Patent Office.

EDMUND B. KIRBY, of Rossland, Canada.

Application Filed December 14, 1903; Serial No. 185,033.

No. 809,959. Specification of Letters Patent. Patented January 16, 1906.

Process of Separating Minerals.

To all whom it may concern:

Be it known that I, Edmund B. Kirby, a citizen of the United States, residing at Rossland, in the Province of British Columbia and Dominion of Canada, have invented a certain new and useful Improvement in Process of Separating Minerals, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings.

The invention relates to the concentration of ores. It may be employed to separate the metallic minerals from the gangue, or to separate certain of the metallic minerals from others, or from others and the gangue.

The operation of the process is dependent upon the fact that, because of differences in physical characteristics of the various constituents of mineral material, such constituents show preferences of adhesion between two commingled, but immiscible liquids.

The invention consists in the process hereinafter described, and in the several steps thereof, all of which will be definitely set forth in the claims.

In the drawings, Figure 1 is a diagrammatic view of an apparatus with which the process may be practiced, the several parts thereof being shown in vertical section. Fig. 2 is a plan view of one side of the separating-tank. Fig. 3 is a vertical sectional view of the same mechanism. Fig. 4 is an elevation of a part of the agitator mechanism of the separating-tank, some of said mechanism being in section; and Fig. 5 is a plan view of one of the agitator-arms and a sectional plan view of the shaft.

The process is applicable to a great variety of ores, and may be practiced in many cases so as to separate those metallic minerals

which must be treated in one way from those which must be treated in some other way in order to recover their contained commercial metals, and since it is capable of being used for this purpose as well as to separate the metallic minerals from the gangue it is thought to be a great step in advance of this art.

It is believed that the process or some of the novel steps thereof may be employed with advantage in the treatment of all ores. It is obviously impossible, however, to give definite directions for attaining the best results with all ores, because of the great chemical and physical differences which they exhibit. The detailed directions hereinafter set forth are those which are found most efficient in the treatment of the Rossland, British Columbia, ores, with which I have done the most work, for the primary purpose of separating the chalcopyrite (which must be smelted) from the other constituents which may be subjected to other after treatment for the recovery of their contained metals.

The process, as an entirety, in its best form for use with Rossland ores for the purpose stated consists in the following steps:

First, in thoroughly agitating together (*a*) the pulverized ore or mineral material (*b*) enough water to make with said pulverized ore a flowing pulp, and (*c*) a solution of bitumen in a thin distillable hydrocarbon liquid as kerosene, these materials to be so thoroughly agitated together as to finely subdivide said solution into small globules and bring said globules into contact with substantially all of the pulverized mineral particles which will, by preference, adhere to them.

Second, in allowing the hydrocarbon-coated particles to float to the surface of the mass, and in rendering this separation substantially complete by gently agitating the mass, and by injecting gas into the same, and preferably also discharging into the mass fine streams of the solution. When the separation is completed, the floating hydrocarbon-coated concentrate is removed for subsequent treatment.

Third, in filtering said concentrate to free it so far as possible from the hydrocarbon liquid.

Fourth, in distilling said coated concentrate and condensing the hydrocarbon vapor to be used again.

It is thought that the use of a gas to assist in the flotation of the coated particles, as set forth in the description of the second step of the process, is radically new in this art, irrespective of its association with the other steps described. It is that which makes it possible for the first time to use thin oils and hydrocarbon. The prior processes which use thick, viscous oils will, however, be much aided by the addition of this step, because in spite of all the care which is exercised in the practice of those processes to keep the oil in large clots or masses a great deal of it is "floured" or broken up into minute particles which are trapped in the sands and lost. The employment of the gas in the manner stated brings in a more powerful floating agency than anything before used, which
1222 results in the recovery of this floured oil together with numerous coated particles which would not otherwise be floated.

This step of the process is therefore useful with any and all liquids lighter than water which exhibit preference of adhesion for the metallic mineral particles. Kerosene alone, for example, may be used with most ores to take out the sulfids provided the gas is used, as stated, to cause the flotation of the kerosene-coated particles. It is the bitumen, however, dissolved in the kerosene which gives the precise adhesive preference which enables it to separate the gold and chalcopyrite from the crushed ore. The bitumen may be alphalt or the bitumen produced by the distillation of petroleum to a semisolid residuum, or it may be tar, pitch, or any other specific form of bitumen. In treating Rossland ores I have found that the most satisfactory results have been attained by using a solution obtained by dissolving in kerosene about five per cent. or thereabout of Trinidad asphalt or the semisolid residuum of petroleum distillation. Preferably the pulverized ore is mixed with three to five times as much water, by weight, and to this is added a sufficient amount of the kerosene-bitumen solution, excellent results being obtained by using one-fourth to three-fourths as much, by weight, as ore. The preference of the solution for some of the mineral particles may be regulated by altering or varying the quantity of the solute substance and by varying the temperature at which the solution is used. The preference of the water for other mineral particles may be regulated by adding some acid or other chemical. A distinct advantage of using a light hydrocarbon, like kerosene, is that so much of it as cannot be removed from the concentrate by mechanical means may be recovered by a process of distillation, this method of recovery being impossible when thick non-distillable oils are used. The injection of a gas, preferably air, into the mass, which the chief novel characteristic of the second step of the process, assists in the flotation of the hydrocarbon-coated particles. This makes it possible to finely subdivide the solution by the agitation, and this greatly increases the chance that all of the mineral particles which exhibit preferential adhesion for it shall be brought into contact with it. Some of the hydrocarbon-coated particles will float to the surface without assistance; but a considerable quantity of such particles will not be sufficiently buoyant, and some of such particles and some globules of the mixture would be trapped in the sands. In order to recover this less buoyant material together with the globules of the mixture, the mass which tends to settle is slowly lifted and turned over to liberate the coated particles and the globules, and at the same time a gas, preferably air, is blown into the mass preferably near the bottom thereof. The air-bubbles not only tend to attach themselves directly to the coated particles, and thus float them to the surface, but the air becomes dissolved in the water to its maximum capacity. This dissolved air tends to again separate itself from the water and attach itself in minute globules to the coated particles. I find that air, carbon dioxid, hydrogen, and marsh-gas are satisfactory for this purpose, and doubtless many other or all gases will operate in the same way, but I prefer air. It might be here added that because the solution is broken up into small globules there is little likelihood that any of the non-coated particles shall be entangled with the coated

concentrates and carried to the surface. In removing this floating hydrocarbon-coated concentrate it is practically impossible to exclude some of the water in which the non-coated particles are held in suspension. It is therefore desirable that this concentrate shall be washed free from such non-coated minerals. This step is not, however, absolutely essential. It is possible to remove a very large part of the hydrocarbon by filtration, because of its thin character. It is not, however, possible to remove it all by this or any other mechanical process; but because of the character of the hydrocarbon solvent used it is possible to recover all of it for future use by a process of distillation which constitutes the fourth step of the complete process.

I will now describe the apparatus shown in the drawings for practically carrying on said process.

A represents the mixing-tank.

B represents the separating-tank.

C represents the settling-tank.

D represents the filter, and E another filter, which may or may not be used according to circumstances.

G represents a settling box or tank into which the liquid from the filter or filters is discharged.

H represents the retort-furnace; I, the dust-collector used in connection therewith; J, a condenser; K, the settling-tank, in which the condenser discharges the condensed vapor, and M represents a reservoir from which the solution may be fed into the mixing-tank and into the separating-tank.

In the separating-tank B is a vertical shaft *b*, having on its upper end a gear *b'*, by which it may be rotated. The head of the shaft above the driving-gear passes through an oil and air box 1, which remain stationary while the shaft revolves and is supplied by the hydrocarbon-pipe 2 and the air-pipe 3. The box rests on the rotating shoulder 4 of the shaft and is held down to a tight joint by the collar 5 and lock-nut cap 6. Through the hollow shaft 7 extends a small hydrocarbon-pipe 8, the upper end of which is firmly inserted within the upward extension 10 of the shaft, and this central pipe conveys the hydrocarbon. In the stationary box the air enters the annular chamber 11, passing through its open bottom through a set of apertures 12 to the interior of the shaft. The hydrocarbon enters a similar annular chamber 13, from which it passes by apertures 14 into the top of the central hydrocarbon-pipe. The hub and revolving arms are shown in Figs. 4 and 5. The step-bearing is supported on a pedestal 15, provided with a wooden block 16, which supports the moving wearing-plate 17 of the shaft. Lubricating-water under pressure is introduced through the pipe 18, finding its way out from the bearing through side grooves 50. The sides 19 of the shaft are carried down below the bearing, so as to leave an annular space 20 between them and the pedestal. This annular space is intended to constitute an air-bell designed to assist the lubricating-water in excluding sand from the bearing. The air-supply in it is maintained by a slight stress of air which escapes beneath the bell through the pipe 21. The air-current for the charge passes down through the shaft, passing (as shown by the arrows) through the

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side channels 22 into the hollow arms 23 23. From each arm it passes out through drop-pipes 24 24. The hydrocarbon liquid is delivered through small pipes parallel with said hollow arms, emerging at the outlets 25 25. The radially-scraping blades 26 26 are secured to the arms 23 and also the inclined-lifting plow 27 at the extremity of the said arms, this being so set as to force the circulation upward at this point. The rotary movement of the charge leads the floating scum of hydrocarbon liquid, air-bubbles, and concentrates against the curved skimming-bar 28, which is hung so as to arrest and deflect this floating layer and cause it to pass into the settling and washing chamber or box 29. The edge of this box outside of the skimming-bar is submerged sufficiently to allow the floating material to pass over it, while the remaining part of said edge is raised above the liquid, so as to detain everything passing into it. Owing to the agitation within the tank caused by the movement of the arms 23 and the rising air-bubbles the water, even near the top, is not clear, but turbid or muddy, with slimes or fine particles of the non-coated minerals which do not settle rapidly enough to get out of the way. The floating concentrates are carried mainly at the lower surface of the hydrocarbon layer, where it is in contact with the water. The discharge-gate 32 in order to permit these floating particles to pass out must be set low enough to clear them, and must therefore allow a portion of the water to pass out with the skimmings, and this muddy water would therefore carry its suspended particles of the worthless minerals, which would make the concentrates impure. The settling and washing chamber or box is designed to lessen or prevent this evil. As the floating material passes over its submerged edge 29 30 to escape from the swift current and rising air-bubbles, so that in its comparative quiet the slimes have a better opportunity to settle out of the way. The bottom of the box is divided as convenient into compartments by submerged partitions, as shown, each compartment terminating in a hopper-shape bottom with discharge-openings 33, through which the settled slimes may pass out again into the tank. Projecting shields 34 prevent the air-bubbles from entering the hoppers and disturbing their quiet. The passage of the floating material over this quiet chamber or box settles most of the slime before reaching the adjustable discharge gate or outlet 32. Before reaching the gate, however, the skimmings pass over a stream of clean wash-water introduced at the point 35 through the pipe shown. This wash-water is delivered under constant head from a supply-tank. Its quantity is made exactly equal to that passing out through the discharge-gate with the skimmings, so that this discharge, being supplied entirely by the pure water close at hand, contains little or none of the muddy water which is thus held back in the tank. It is evident that the incoming and outgoing streams are self-adjusting, because if too much enters the general level rises and a larger stream flows from the orfice.

In the mixing-tank a vertical rotating shaft *a* is mounted having, preferably, a lower bearing similar to that which is provided for shaft *b* and which has been described. Arms *a'* are attached to the shaft near its lower end, and lifting-plows are secured to the outer

parts of these arms and radial plows to the other parts thereof, just as in the separator-tank. This shaft *a* is to be rotated rapidly, and the result is a thorough commingling of the various parts of the charge, which result is facilitated by the currents created in the charge by the action of said plows, the direction of said currents being indicated by the arrows in Fig. 1. This separate tank for performing the mixing operation is not necessary for my process, although it is preferable in some cases, as when a continuous discharge is desired. The mixing may be performed just as well in the separating-tank, which may then be termed the "mixing" and "separating" tank. It is merely necessary to rotate the agitating mechanism rapidly while mixing and to rotate it slowly while the separation is being made.

The material skimmed from the surface of the separating-tank may pass directly to the filter D or E; but it is best to discharge it into the settling-tank C in order to separate the main bulk of water,
1224 and thus reduce the bulk of liquid to be put through the filtering operation. As explained, this is not essential, but is conveniently introduced prior to the filtration merely in order to separate the main bulk of water, and thus reduce the bulk of fluid to be put through the filtering operation. It is thus merely a convenience. The settling-tank C is shown as a cylindrical vessel with hopper-shape bottom, within which is suspended a cylinder 41, reaching half-way down. The stream of skimming enters this central cylinder, within which the water and hydrocarbon separate, the former sinking, while the latter, with its accompanying concentrates and air-bubbles, floats in a layer, as shown. The stirring apparatus 42 has its arms revolving gently within this layer, so as to break up and discharge air-bubbles and assist the separation. Most of the concentrates hang near the contact between the hydrocarbon and water, and as this contact-surface becomes overloaded with concentrates some of them sink to the bottom of the tank. The excess of hydrocarbon, accompanied by some of the concentrates, flows out through the launder 43, while the excess of water passing beneath the suspended internal cylinder passes out through the overflow 44, and thereby lessens the volume to be filtered. The concentrates which fall to the bottom of the tank, accompanied by the hydrocarbon which adheres to them, are drawn off in a thick condition through the pipe 45, the discharge end of which is raised to prevent the exit of more water than necessary. The two streams, one of hydrocarbon and concentrates, the other mainly of water and concentrates, may either be filtered in separate apparatus or united and put through the same apparatus, as is found most convenient. Hydrocarbon liquid and concentrates filter more easily than when water is present, and it may therefore be desirable to filter separately. It is for this reason that two filters D and E are shown, the one receiving such material as flows from the surface of the tank through launder 43 and the other that material which is discharged through pipe 45. I do not restrict myself to any particular form of filtering appliance.

The use of thin hydrocarbon liquid in place of the thick viscid oils used by other inventors makes filtration comparatively easy and

permits the use of more simple and cheap methods than the centrifugal machine or filter-presses. The use of such simple apparatus is also made possible by the fact that it is not now necessary to separate the liquid very thoroughly, since its extraction is to be perfected in the distillation-retorts. I find that in some cases it is sufficient to use a simple open filter-tank with a porous bottom of any of the well-known kinds, preferably light canvas, resting on suitable supports. The liquid and water drain through the porous bottom, leaving the concentrates in the tank sufficiently drained to be shoveled into the retorts. The passage of the liquid and water through the porous bottom is aided by the well-known means of a vacuum-pump N beneath. The filter (indicated by E) is a pressure-filter barrel of well-known construction, which need not be here explained, and may be used when forced filtration is necessary. It is shown to emphasize the fact that the operation of the process is not restricted to any specific kind of filter or to any number of filters. The mixture of hydrocarbon liquid and water now free from solid matter is of course self-separating in any receptacle. A convenient form is shown in the settling-box G, into which said mixture is delivered through suitable pipes from both filters. The hydrocarbon liquid remains in one compartment *g*, from which it overflows and is returned to the reservoir. The water sinking to the bottom passes under the partition *g'* to the other compartment and flows to waste. The filtered concentrates containing some residual liquid and moisture are now ready for the distilling operation for the recovery of the five per cent. or more of valuable hydrocarbon liquid remaining in them. This is done in the retort-furnace H. An iron retort 46 is set in a furnace at such an angle that the concentrates will pass down through it by gravity, but will not altogether close the upper side of the channel, which should remain more or less open for the exit and passage of the steam and hydrocarbon vapors. The retort is maintained at the distillation temperature of the hydrocarbon used, which in the case of kerosene is about 338° Fahrenheit. In order to assist in carrying off the hydrocarbon vapor, a current of superheated steam is introduced at 47, while the steam and hydrocarbon vapors pass off through the pipe at 48 to the condensing apparatus. The dry concentrates on losing their liquid and moisture slide down to the lower end of the retort, where they are drawn off through the double gates 49 49, which are opened alternately, so as to prevent the escape of vapors. As concentrates are drawn off below a fresh mass is introduced above by the alternate opening of the gates 50 50, which likewise prevent the escape of vapors. An additional seal is provided by the hopper 51, which is kept filled with concentrates. The steam and hydrocarbon vapors may be led through a dust-collecting chamber I, designed to settle and collect any concentrates dust carried over, and then passes to the condenser J. This includes a metal worm or coil 53, set in a tank through which a stream of cooling-water is allowed to flow.

The condensed hydrocarbon and water passing through a 1225 U-trap 54 flow into a settling-box K, similar to the one described at G. Here the hydrocarbon liquid and water separate, and the former is returned to the reservoir M for reuse, as is also the liquid recovered in the settling-tank G.

Having described my invention, I claim—

1. The process of separating minerals, which consists in mixing together pulverized mineral material, a considerable quantity of water, and a substance immiscible in water, but of less specific gravity, and which will, in the presence of water, adhere to some of the mineral particles and not to others; in violently agitating the mass so as to break up said immiscible substance into minute globules; in allowing said mass to settle whereby a considerable quantity of the mineral particles having become coated with said substance will float to the top of the mass, and in gently agitating the portion thereof which settles, and in blowing into the same a gas for the purpose of assisting the flotation of said substance and the mineral particles coated therewith; in removing the floating layer, and in separating the mineral particles from said immiscible substance, substantially as specified.

2. The process of separating ores, whch consists in mixing together pulverized mineral material, a considerable quantity of water, and a solution of bitumen in a light hydrocarbon liquid, the proportion of bitumen in solution being substantially sufficient to insure coating and entrainment of the mineral particles; in violently agitating this mixture to break up said solution into fine globules; in allowing the mass to settle, and then gently agitating the same and blowing in gas to insure the flotation of said solution and the mineral particles coated thereby; in removing the floating layer; and separating the mineral particles from the solution, substantially as specified.

3. The process of separating ores, which consists in mixing together pulverized mineral material, a considerable quantity of water, and a solution of bitumen in a light hydrocarbon liquid, the proportion of bitumen in solution being substantially sufficient to insure the coating and entrainment of the mineral particles; in violently agitating this mixture to break up said solution into fine globules; in allowing the mass to settle, and then gently agitating the same and blowing into it a gas and some of the said solution to insure the flotation of said solution and the mineral particles coated thereby; in removing the floating layer; and separating the mineral particles from the solution, substantially as specified.

4. The process of separating minerals, which consists in mixing together the pulverized mineral material a considerable quantity of water, and a solution of bitumen in a light hydrocarbon liquid; in allowing the same to settle, and removing therefrom the floating layer of said solution and the mineral particles which have been coated thereby; and in filtering the material so removed, substantially as specified.

5. The process of separating minerals, which consists in mixing together the pulverized mineral material, a considerable quantity of water, and a solution of bitumen in a light hydrocarbon liquid, the proportion of bitumen in solution being substantially sufficient to insure the coating and entrainment of the mineral particles; in gently agitating this mixture and blowing gas into the same to assist the flotation of said solution and the mineral particles which have

been coated thereby; in removing said floating layer; and filtering the same, substantially as specified.

6. The process of separating minerals, which consists in mixing together the pulverized mineral material, a considerable quantity of water, and a solution of bitumen in a distillable hydrocarbon liquid, the proportion of bitumen in solution being substantially sufficient to insure the coating and entrainment of the mineral particles; in allowing the same to settle, and removing therefrom the floating layer of said solution and the mineral particles which have been coated thereby; in filtering the materials so removed; and in distilling the concentrate residue and condensing the hydrocarbon vapors driven off, substantially as specified.

7. The process of separating minerals, which consists in mixing together the pulverized mineral material, a considerable quantity of water, and a solution of bitumen in a distillable hydrocarbon liquid; in gently agitating this mixture and blowing gas into the same to assist in the flotation of said solution and the mineral particles which have been coated thereby; in removing the floating layer, and filtering the same; and in distilling the concentrate residue and condensing the hydrocarbon vapors driven off, substantially as specified.

8. The process of separating minerals, which consists in mixing together the pulverized mineral material, a considerable quantity of water, and a solution of bitumen and kerosene; in gently agitating this mixture, and in blowing a gas into the same to assist in the flotation of said solution and the mineral particles which have been coated thereby; and in separating said solution and mineral particles, substantially as specified.

9. The process of separating minerals, which consists in mixing together the pulverized mineral material, a considerable quantity of water, and a solution of bitumen in kerosene, and vigorously agitating this mixture so as to break up said solution into minute globules; in gently agitating said mixture and blowing a gas into the same to assist in the flotation of said solution and the mineral particles coated thereby; in removing the floating layer; in washing and filtering the same; and finally in distilling the concentrate residue and condensing the hydrocarbon vapors driven off, substantially as specified.

1226

In testimony whereof I hereunto affix my signature in the presence of two witnesses.

EDMUND B. KIRBY.

Witnesses:
T. L. SAVAGE.
E. G. EASTMAN.

1227 [DEFENDANT'S EXHIBIT DRAWING AND SPECIFICATION OF LETTERS PATENT NO. 835,143, PATENTED NOVEMBER 6, 1906, ISSUED TO H. L. SULMAN.]

(Here follows diagram marked p. 1228.)

1229 United States Patent Office.

No. 835,143. Patented Nov. 6, 1906.

HENRY LIVINGSTONE SULMAN, of London, England.

Ore Concentration.

No. 835,143. Specification of Letters Patent. Patented Nov. 6, 1906.

Application Filed October 20, 1905. Serial No. 283,704.

To all whom it may concern:

Be it known that I, Henry Livingstone Sulman, a subject of the King of England, residing at London, England, have invented certain new and useful Improvements in Ore Concentration, of which the following is a specification.

This invention relates to improvements in the concentration of ores, the object being to separate metalliferous matter, graphite, and the like from gangue by means of oils, fatty acids, or other substances which have a preferential affinity for metalliferous matter over gangue.

In the process described in the specification of the previous patent application, Serial No. 262,889, filed May 29, 1905, a mineral pulp is agitated with a small proportion of an oily substance, such as oleic acid or petrol or other oil, amounting to a fraction of one per cent. on the ore until the oil-coated metalliferous matter forms into a froth which can be separated from the gangue by flotation, the pulp being acidified. It is also stated that the pulp may be warmed, say, to 30° to 40° centigrade to increase the tendency for the oily substance to disseminate through the pulp and the rapidity with which the metalliferous matter becomes coated.

It is now found that if the finely-powdered ore suspended in water is mixed with a small proportion of an oily substance—say five per cent. or less of the ore—agitated and heated to a high temperature—say, to boiling-point—that is to say, to a temperature at which bubbles of steam or vapor are generated in the pulp—the formation of a froth containing the oil-coated metalliferous matter is consider-

No. 835,143. PATENTED NOV. 6, 1905.

H. L. SULMAN.

ORE CONCENTRATION.

APPLICATION FILED OCT. 20, 1905.

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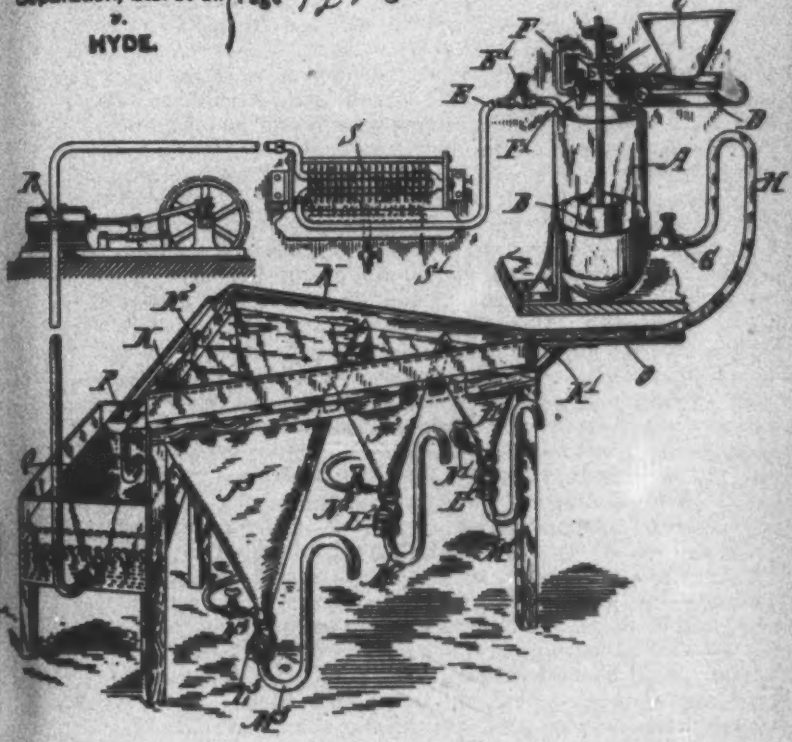

Witnesses
H. A. Totten
[illegible]

Inventor
Henry Livingstone Sulman
by Knight Bros
Attorneys

ably promoted, and a very efficient separation of the metalliferous matter from the gangue may thus be obtained.

The water in which the oiling is effected may be slightly acidified by adding, say, a fraction of one per cent. of sulfuric acid or other mineral acid or acid salt, or the water may be neutral or alkaline. It is to be understood that the object of using acid in the pulp according to this invention is not to bring about the generation of gas for the purpose of flotation thereby, and the proportion of acid used is insufficient to cause chemical action on the metalliferous minerals present.

The quantity of oil employed is not sufficient to cause the flotation of the metalliferous matter by the buoyancy of the oil; but the quantity may be sufficient—say five per cent. or less on the quantity of ore—to coat the metalliferous particles with a thin film of oil.

The following is an example of the application of this invention to the concentration of ore: Broken Hill or certain copper ores are finely powdered and mixed with water, acidified or not. To this is added a proportion, as above described, of an oily substance, such as oleic acid, and the mixture is agitated in a cone mixer or the like in order to effect due oiling of the mineral particles. The pulp may now be removed from the agitation (oiling) vessel and subjected to heat in suitable apparatus. As the liquor becomes heated, and especially as the boiling-point of the liquor is approached, a froth or scum rises to the surface containing practically the whole of the metalliferous matter, while the gangue remains in the pulp. The froth may be removed from the liquid by skimming or in any usual way, or the frothy portion may be separated from the remainder of the pulp by causing this to flow through a spitzkasten or the like. The froth after separation and collection may be allowed to subside, and the oily substance may be removed from the metalliferous matter by treatment with an alkali or a solvent or otherwise.

The heating of the pulp may be effected by means of closed steam-coils, or of free steam-jets, or surrounding the agitating vessels with steam-jackets, or by any other suitable means, or the treatment of the pulp by heat may be made continuous by causing it to flow over heated surfaces in a continuous stream and collecting the suitably-heated product in an apparatus wherein the separation of the froth so produced from the mineral-depleted ore-pulp can be effected; or the contents of the agitation (oiling) vessel may be heated to the necessary extent, which approaches the boiling temperature, and on cessation of agitation the mineralized froth rises to the surface.

Should any coarser particles of oiled mineral (unremoved as "froth,") remain in the coarse sands of the separated pulp, these particles may be recovered by passage over a concentration or aeration apparatus or the like.

It is to be understood that the details of the process may be varied without departing from this invention.

The accompanying drawing is a per-pective view of one form of apparatus suitable for carrying this invention into practice,
1230 the arrangement being such that the contents of the agitation vessel may be heated to the necessary extent.

A mixing vessel A (of which there may be any number in series) is provided with a rotatable stirrer B. Crushed ore is fed from a hopper C into the vessel by a band D. A pipe E, controlled by a tap E′, delivers circuit-water to the vessel, and oleic acid or other oil is introduced through the pipe F and tap F′. The outer cock G from the vessel A communicates, through a swan-neck pipe H, with the froth-separating apparatus.

In passing from the frothing apparatus A to the spitzkasten (say between O and K) the pulp may, if desired, be run in a thin layer over a smooth slightly-inclined plane.

The froth-separating apparatus comprises several (say three) pointed boxes J′ J^2 J^3, which open at the top into a horizontal channel consisting of side walls K. The channel has a narrow inlet K′ and spreads out to a wide outlet K^2. The pointed boxes J′ J^2 J^3 have full-way cocks L′ L^2 L^3 at the bottom leading to swan-neck discharge-pipes M′ M^2 M^3. An upcurrent of water may be led in at the bottom of each box through a tap N′ N^2 N^3.

The boxes are all filled with circuit-water. The pulp from the vessel A is distributed horizontally from the flat trough O through the inlet K′. The heavy sands and coarser particles of mineral sink into the first box J′, from which they are led to a shaking-table, convex buddle, or the like, to be treated as above described. The middlings or medium sands fall into the box J^2, and if they contain any mineral may be removed for further treatment by agitation. The upcurrent of water from the taps N′ N^2 prevents the deposition of any slime in these boxes. The fine sands or gangue slimes settle in the last box J^3, from which they are discharged to waste or further treatment.

The slime mineral in the form of froth or scum floats from the liquid and is carried by the stream over the outlet K^2 into a launder P and thence to a filter Q, where the metalliferous matter is removed from the circuit-water, which is returned to the vessel A by a pump R. The circuit-water may be brought to the proper temperature approximately to boiling-point by passing it through a heater S, having a burner S′, before admitting the water to the vessel A.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The herein-described process of concentrating ores which consists in mixing the powdered ore with water, adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter, agitating the mixture, heating the mixture approximately to boiling-point until the oil-coated mineral matter forms into a froth and separating the froth from the remainder by flotation.

2. The herein-described process for concentrating ores which consists in mixing the powdered ore with water, adding a small proportion of oily liquid having a preferential affinity for metalliferous matter, agitating the mixture, heating the mixture until gaseous bubbles are generated therein so that the oil-coated mineral matter forms into a froth and separating the froth from the remainder by flotation.

3. The herein-described process of concentrating ores which con-

sists in mixing the powdered ore with slightly-acidified water, adding a small proportion of oily matter having a preferential affinity for metalliferous matter, agitating the mixture, heating the mixture approximately to boiling-point until the oil-coated mineral matter forms into a froth and separating the froth from the remainder by flotation.

4. The herein-described process of concentrating ores which consists in finely powdering the ore, mixing it with slightly-acidified water, adding a small proportion of an oily substance having a preferential affinity for metalliferous matter in quantity insufficient to cause the flotation of the metalliferous matter by the buoyancy of the oil, agitating the mixture, heating the mixture to boiling-point until the oil-coated mineral matter forms into a froth, separating the froth from the remainder by flotation and removing the oil coating from the mineral by a solvent.

5. The herein-described process of concentrating ores which consists in finely powdering the ore, mixing it with water containing less than one per cent. of sulfuric acid, adding a proportion of less than ten per cent. of oleic acid, agitating the mixture until the oleic acid has come into sufficient contact with the mineral, heating the mixture up to boiling-point until the metalliferous matter has been raised in a froth to the surface, running the mixture over a current of water so that the froth is floated away by the current while the remaining mineral sinks, separating the froth and removing the oleic acid therefrom by a solvent.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

HENRY LIVINGSTONE SULMAN.

Witnesses:
R. WILLIAMS.
T. B. BUSS.

6833

1231 [DEFENDANT'S EXHIBIT DRAWING AND SPECIFICATION OF LETTERS PATENT No. 835,479, PATENTED NOVEMBER 6, 1906, ISSUED TO H. L. SULMAN ET AL.]

(Here follows diagram marked p. 1232.)

1233 United States Patent Office.

HENRY LIVINGSTONE SULMAN, HUGH FITZALIS KIRKPATRICK-PICARD, and JOHN BALLOT, of London, England, Assignors to Minerals Separation, Limited, of London, England.

Ore Concentration.

No. 835,479. Specification of Letters Patent. Patented Nov. 6, 1906.

Original Application Filed May 29, 1905. Serial No. 262,889.

Divided and This Application Filed January 9, 1906. Serial No. 295,326.

To all whom it may concern:

Be it known that we, Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard, and John Ballot, subjects of the King of England, residing at London, England, have invented certain new and useful Improvements in Ore Concentration, of which the following is a specification.

This invention relates to improvements in ore concentration, and this application is a division of an application filed by us on May 29, 1905, Serial No. 262,889.

Several methods are known in which air and other gas is introduced, generated, or liberated in a pulp containing powdered ore in suspension, whereupon the gaseous films or bubbles attach themselves to certain particles, which are thereby caused to float, while other particles are not so floated.

The object of this invention is to improve such processes.

The invention is particularly applicable to the separation of oiled mineral particles from unoiled particles in a pulp; but it is also applicable in some cases in which gaseous bubbles will selectively adhere to certain particles without the use of oil.

Among the previous processes depending upon gaseous flotation is that described in our previous United States patent, No. 793,808, dated July 4, 1905, in which the flotation of oiled mineral particles

No. 835,479. PATENTED NOV. 6, 1906.

H. L. SULMAN, H. F. KIRKPATRICK-PICARD & J. BALLOT.

ORE CONCENTRATION.

APPLICATION FILED JAN. 9, 1906.

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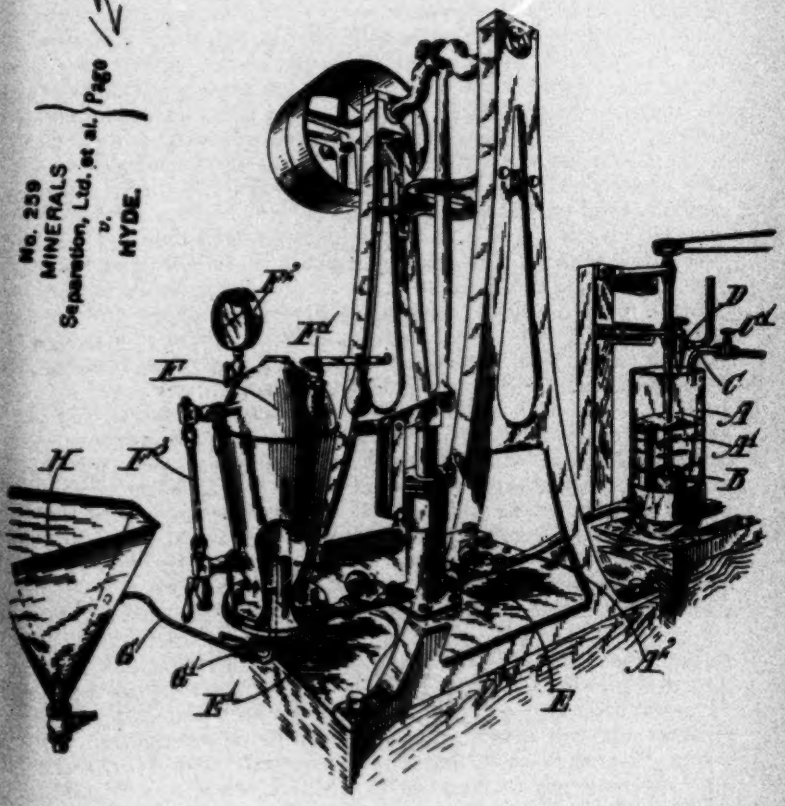
Page 1232



Witnesses
A. L. Knight.
H. H. Simmons

Inventors
Henry L. Sulman
Hugh F. Kirkpatrick-Picard
and John Ballot
by Knight Bros
Attorneys

is brought about by the liberation of a gas in the pulp containing them.

According to this invention it is found that a convenient method of effecting the liberation or generation of gas-bubbles in such a pulp is to subject the latter to the action of compressed air or other compressed gas in a suitable vessel or apparatus from which the pressure can be subsequently relieved. If, for example, the ore-pulp after agitation with a small proportion of oil or other suitable substance having a preferential affinity for metalliferous minerals be subjected to the action of compressed air at a pressure of, say, fifty to one hundred pounds per square inch and after the lapse of a few minutes for the due solution of the compressed air or a portion of it by the pulp or the liquid be allowed to discharge itself into an open vessel at the normal atmospheric pressure, the whole of the oiled mineral will at once rise to the surface of the pulp as a coherent scum or froth, which can be removed by skimming or by a surface current of water from the ganuge, which remains sunk or suspended in the remainder of the pulp. A spitzkasten is a suitable type of vessel into which the superaerated pulp may be discharged. We have found this method very efficacious in cleaning up finely-divided ore products which have been submitted to oiling. We do not confine ourselves to the use of atmospheric air, as it is obvious that any suitable gas which is soluble in water to a sufficient extent under pressure and which preferentially attaches itself to oiled mineral particles may be employed to thus effect the gaseous flotation of the oiled mineral particles. It is to be understood that we do not use pressures below the normal atmospheric pressure at the time being in any portion of the operation.

The accompanying drawing represents in perspective view one form of the apparatus suitable for carrying this invention into effect.

A mixing vessel A (of which there may be several in series) is provided with a rotatable stirrer B. Crushed ore or similar finely-divided mineral is fed into the vessel A. A pipe C, controlled by a tap C′, delivers circuit water to the vessel, and in cases where oil is used the oil is introduced through the pipe D in quantity sufficient to produce a thin coating of oil on these mineral particles, for which oil has an affinity.

The pulp mixed with oil escapes over the lip of a discharge-conduit A' and passes through the pipe A^2 to a pump E. Hence the pulp is pumped through discharge-pipe E′ into the closed chamber F, which is constructed to withstand a considerable internal pressure and is provided with a safety-valve F', the pressure-gage F^2, and a gage-glass F^3 to indicate the level of the pulp in the chamber. An outlet-pipe G, having a cock G′, leads to a series of spitzkastens H, filled with circuit-water.

The operation is as follows: The cock G′ is closed. Pulp is pumped into the chamber F, which contains air or other gas, and the pumping is continued until the pressure in the chamber rises to, say, fifty to one hundred pounds per square inch. The
1234 pressure is sufficient to cause the air or other gas to be dissolved to a considerable extent in the pulp. After the lapse

of a few minutes for the due solution of the compressed air or a portion of it by the pulp or the liquid the cock G′ is opened and the pulp is discharged into the open spitzkasten H, where the liquid is of course under atmospheric pressure. The pump E may be stopped during this discharge. The whole of the mineral to which air-bubbles are attached—say the oiled mineral—at once rises to the surface as a coherent scum or froth. A surface current of water is maintained in the spitzkasten, and the floating material is thus removed and separated from the gangue, which remains sunk or suspended in the liquid.

It is to be understood that the expression "oil" includes any substance, such as oleic acid, which has a preferential affinity for certain mineral substances over others.

Having thus described our invention, what we claim, and desire to secure by Letters Patent, is—

1. The process of separating powdered minerals from one another which consists in suspending the powdered minerals in a liquid, subjecting the mixture to a gas-pressure and thereafter relieving the pressure whereby bubbles of gas are liberated in the pulp and carry certain minerals to the surface.

2. The process of separating powdered minerals from one another which consists in agitating the minerals suspended in water with a small quantity of oil, subjecting the pulp to a gas-pressure and thereafter relieving the pressure whereby bubbles of gas are liberated in the pulp and carry the oiled minerals to the surface.

3. The process of separating powdered minerals from one another which consists in agitating the minerals suspended in water with a small quantity of oil, subjecting the pulp to a gas-pressure and thereafter distributing the pulp upon the surface of a column of water whereby the unoiled particles sink while the oiled particles adhering to gaseous bubbles float and are thereby separated.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK-PICARD.
JOHN BALLOT.

Witnesses:
P. WILLIAMS.
H. D. JAMESON.

No. 838,626. PATENTED DEC. 18, 1906.

E. B. KIRBY.

SEPARATING TANK.

APPLICATION FILED DEC. 17, 1906.

2 SHEETS—SHEET 1.

Fig. 1

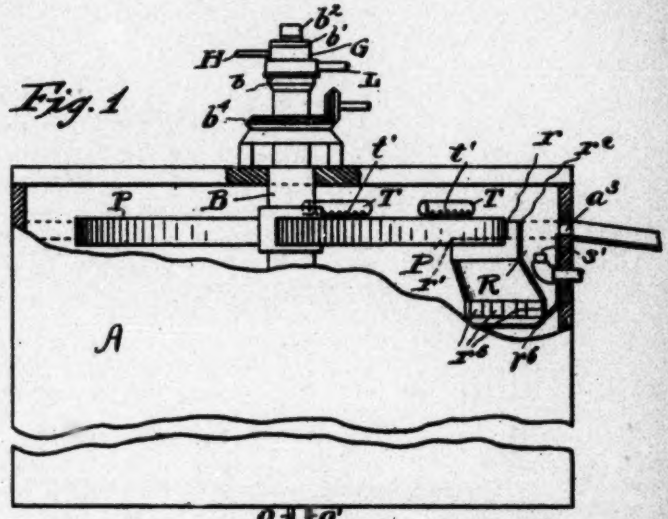
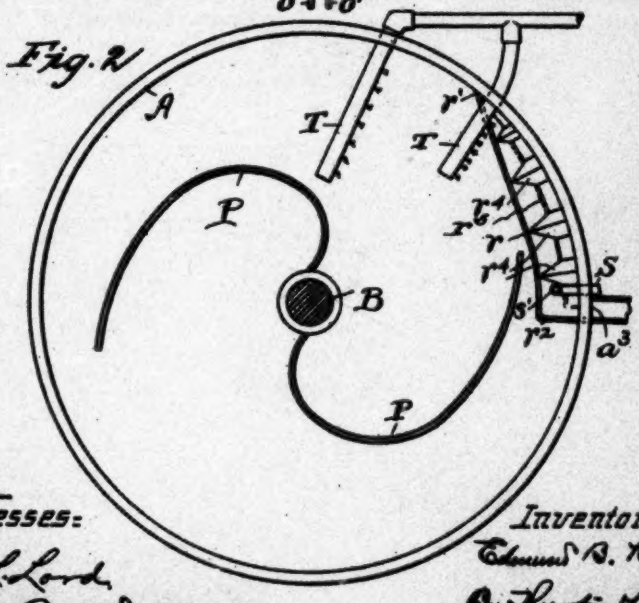


Fig. 2



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Witnesses:
A. L. Lord.
B. B. Brownell.

Inventor.
Edmund B. Kirby
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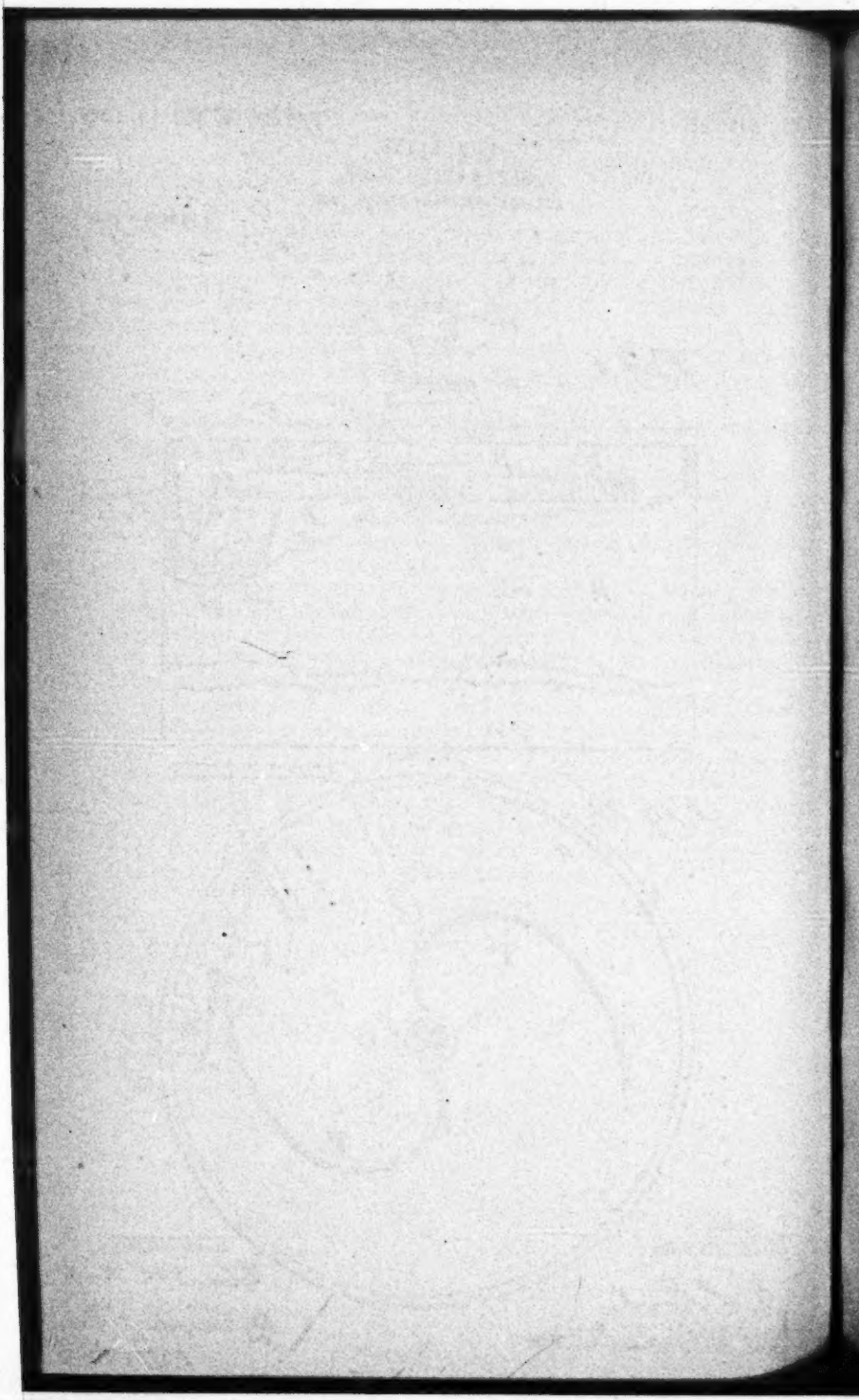
Attorneys.



No. 838,626. PATENTED DEC. 18, 1906.

E. B. KIRBY.

SEPARATING TANK.

APPLICATION FILED DEC. 17, 1903.

2 SHEETS—SHEET 2.

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Fig. 3

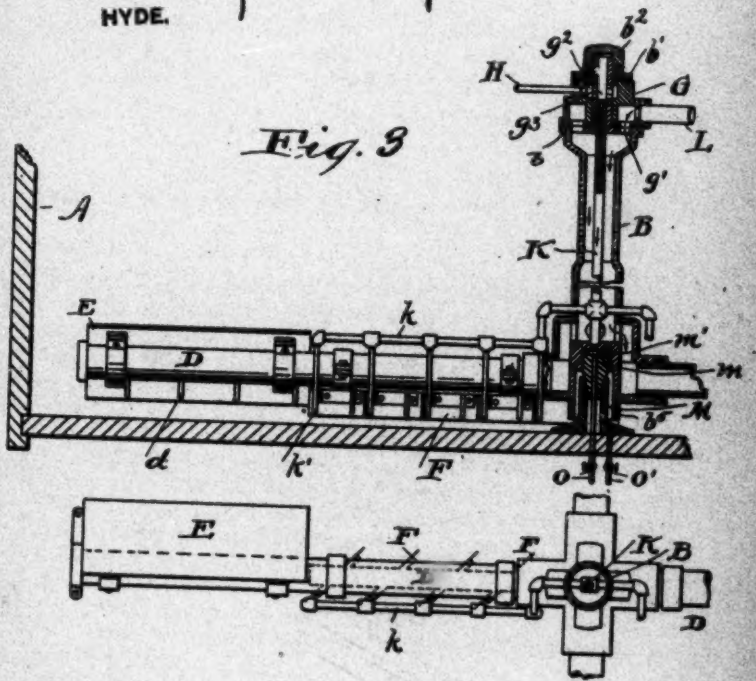


Fig. 4.

Witnesses:
A. L. Lord.
B. W. Brockett.

Inventor.
Edmund B. Kirby
By Thurston & Baker.
Attorneys.

1235 [DEFENDANT'S EXHIBIT DRAWINGS AND SPECIFICATION OF LETTERS PATENT No. 838,626, PATENTED DECEMBER 18, 1906, ISSUED TO E. B. KIRBY.]

(Here follow diagrams marked pp. 1236 and 1237.)

1238 United States Patent Office.

EDMUND B. KIRBY, of Rossland, British Columbia, Canada.

Separating-Tank.

No. 838,626. Specification of Letters Patent. Patented Dec. 18, 1906.

Application filed December 17, 1903. Serial No. 185,475.

To all whom it may concern:

Be it known that I, Edmund B. Kirby, a citizen of the United States, residing at Rossland, in the Province of British Columbia and Dominion of Canada, have invented a certain new and useful Improvement in Separating-Tanks, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings:

The object of this invention is to effect with substantial completeness the segregation of those pulverized mineral particles which have a preferential adhesion for water from those which have a preferential adhesion for a liquid immiscible in water—for example, oil, or a solution of bitumen in kerosene.

This invention is for the treatment of the charge after the pulverized mineral, the oil or solution, and the water have been thoroughly mixed together, whereby nearly all of the mineral particles which exhibit adhesive preference for the oil or solution have been coated therewith.

The invention is most useful when used to carry on one step of a process of my own invention, wherein the immiscible liquid employed is thin and light—as, for example, a solution of bitumen in kerosene, but the invention is also useful with oil processes for separating mineral particles.

This invention, which relates to the separator-tank and its cooperating adjuncts, may be here summarized as consisting in the construction and combinations of parts shown in the drawings and hereinafter described, as definitely set forth in the claims.

In the drawings, Figure 1 is an elevation, partly in vertical section, of an apparatus embodying my invention. Fig. 2 is a plan

view thereof. Fig. 3 is a vertical sectional view of the agitator-shaft and a part of one side of the tank, and Fig. 4 is a sectional plan view of the said shaft and one of the agitator-arms secured thereto below the section-line.

The tank A is preferably cylindrical. Into it is to be charged the materials to be separated—to wit, pulverized ore, water, and some liquid lighter than water and immiscible therein, which will adhere only to the metallic mineral part of the pulverized ore—said materials having preferably been thoroughly mixed in another tank. The immiscible liquid may, as stated, be oil or a light hydrocarbon, or a salution of bitumen in a light hydrocarbon. The apparatus was especially designed for use with a charge consisting of ore, water, and solution of bitumen in kerosene, and therefore the immiscible liquid will for convenience of description be referred to herein as the "solution." The charge should be very fluid and should preferably contain three or four times as much water as mineral, some of which water may be added to the mixture after it has been transferred to the tank A.

Most of the solution and the solution-coated mineral particles rise immediately to the surface, from which they may be skimmed; but considerable quantities of the solution-coated concentrates are enveloped by and entrapped in the sands which settle to the bottom of the tank. For the primary purpose of freeing these particles from the sand and permitting them to float on the surface the vertical rotating agitator-shaft B and its adjuncts are provided. Arms D are secured to this shaft near the bottom of the tank, and as the shaft slowly rotates they gently lift the mass of sands from the bottom and overturn it and prevent it from packing, and thus permit the solution-coated particles to escape and float to the surface. These arms D are provided near their outer ends with lifting-plows E, whose front faces are set at an angle of about forty-five degrees. To these arms between the plows and the central shaft B are secured inclined scraper-blades F, which act to gradually push the material outward into the path of the plows.

It is very desirable that some gas, preferably air, shall be blown into the charge near the bottom thereof. This gas assists in agitating the charge; but its chief value is in the assistance it renders in floating the solution-coated particles to the surface. It is clear that some of these particles may be so large and heavy that the coating thereon may not be able to buoy them up, this being especially true in case the liquid used is thin and light, as the kerosene-bitumen solution. The gas bubbles, however, not only tend to attach themselves to the solution-coated particles and to buoy them up after the fashion of balloons, but the water is caused to dissolve the gas to its maximum capacity. This dissolved gas tends to again separate from the water and attach itself in minute globules to the solution-coated particles, thus buoying them up and assisting their flotation.

1239 It is thought that any gas which will not chemically combine with the charge may be employed in the manner and for the purpose stated; but it is definitely known that air, carbon-

dioxid, hydrogen, and marsh-gas may be so used, air appearing to be rather the most efficient, as well as the cheapest. The gas may be injected in any way and by any means; but very efficient means for this purpose are shown in the drawings, said means consisting generally in making the shaft B and arms D hollow and providing the latter with discharge-openings and blowing the gas down through the shaft. The specific construction is as follows: The head of the shaft above the driving-gear b^4 is provided with a solution and air box G, which remains stationary while the shaft revolves and is supplied by the solution-pipe H and air-pipe L. The box rests on the rotating shoulder b of the shaft B and is held down to a tight joint by the collar b' and lock-nut cap b^2. Through the hollow shaft B extends a small solution-pipe K, the upper end of which is firmly inserted within the upward extension of the shaft and moves with and as a part of it. Air enters the annular chamber g in said box, passing through a set of apertures g' to the interior of shaft B. The solution enters a smaller annular chamber g^2, from which it passes by apertures g^3 into the top of the central pipe K. The air-current for the charge passes down through the shaft into the hollow arms D, from which it passes out through drop-pipes d. The solution is delivered from the pipe K to a series of radiating pipes k, which are secured to the arms D, and is discharged from branch pipes k'. This solution tends to attach itself to those particles not already coated, but which it will adhere to, and thus assists their flotation. The introduction of air and solution renders the separation substantially complete—that is to say, it causes substantially all of the particles which exhibit preferential adhesion for the solution to become coated thereby and floated to the surface.

The shaft B at its lower end has a stepped bearing which is supported on a pedestal M, provided with a wooden block m, which supports the moving wear-plates m' of the shaft. Lubricating-water under pressure is introduced through the pipe O and finds its way out from the bearing into the tank. The sides b^5 of the shaft are carried down below the bearing, so as to leave an annular space between them and the pedestal. This annular space is intended to constitute an air-bell designed to assist the lubricating-water in excluding sand from the bearing. The air supplied to it is maintained by a small stream of air which escapes beneath the bell through the pipe O'.

A spiral skimming-bar P, (two are shown,) which is preferably secured to the rotating shaft B, so as to extend through the floating layer of concentrates, solution, and air-bubbles, acts to direct this floating layer into the settling-chamber R and to the overflow-outlet a^3. This chamber is separated from the rest of the tank by a partition r, the upper edge of which between the points r and r' is submerged sufficiently to allow the floating layer and some of the muddy water to pass over it, while the edge of this partition between the points r and r^2 is raised above the liquid, so as to retain everything passing into it. There is an overflow-outlet a^3 from this settling-chamber through the side of the tank, which outlet is partly surrounded by the elevated part of this partition.

Owing to the agitation within the tank, caused by movement of the arms and the rising air-bubbles, the water even near the top is not clear, but turbid or muddy with slimes or fine particles of the non-coated minerals, which do not settle rapidly enough to get out of the way. The floating concentrates are carried mainly at the lower surface of the floating layer, where it is in contact with the water. The bottom of the overflow-outlet must be below the surface level of the water in order to clear them, and must therefore allow a portion of the water to pass out with the skimmings. This muddy water would therefore carry its suspended particles of the worthless minerals, which would make the concentrates impure.

The settling and washing chamber is designed to lessen or prevent this evil. As the floating material passes over its submerged edge it escapes from the swift current and rising air-bubbles, so that in its comparative quiet the slimes have a better opportunity to settle out of the way. The box is divided into compartments by submerged partitions r^4, as shown, each compartment terminating in a hopper-shaped bottom with discharge-openings r^5 through which the settled slimes may pass out again into the tank. Projecting shields r^6 prevent the air-bubbles from entering the hoppers and disturbing their quiet.

The passage of the floating material over several of these hoppers settles most of the slime before reaching the overflow-outlet. Before reaching the outlet, however, the skimmings pass over a stream of clean wash-water introduced at the point s' through the pipe S shown. This wash-water is delivered under constant head from a supply-tank. Its quantity is made equal to that passing out through the discharge-gate with the skimmings, so that this discharge, being supplied entirely by the pure water close at hand, contains little or none of the muddy water, which is thus held back in the tank. It is evident that the incoming and outgoing streams are self-
1240 adjusting, because if too much enters the general level rises and a large stream flows from the orifice. The flow of the floating layer over the submerged partition of the settling-chamber and on to the overflow-outlet may be induced by properly-directed air-jets blown onto said floating layer from jet-openings t in one or more pipes T.

Having described my invention, I claim—

1. The combination of a separating-tank having an overflow-outlet, and a submerged settling-chamber in said tank discharging through said outlet, with a rotatable skimming-bar supported in said tank for directing the floating layer of concentrates into said settling-chamber and toward said overflow-outlet, substantially as specified.

2. The combination of a separating-tank containing a submerged settling-chamber at one side thereof, through whose side there is an overflow-outlet from said chamber, said chamber being formed by a partition which is partly submerged, and said chamber being divided into a plurality of hopper-shaped compartments, each having a discharge-opening through its lower end, substantially as specified.

3. The combination of a separating-tank containing a submerged settling-chamber at one side thereof, through which side there is

an overflow-outlet from said chamber, said chamber being formed by a partition which is partly submerged, and said chamber being divided into a plurality of hopper-shaped compartments, each having a discharge-opening through its lower end, and a shield below each of said discharge-openings, substantially as specified.

4. The combination of a separating-tank containing a submerged settling-chamber at one side thereof, said settling-chamber having an overflow-outlet through one side of the tank, and said settling-chamber being formed by a submerged partition which projects above the surface of the fluid charge around said outlet but is at other places submerged below the floating layer on the surface of said charge, with a skimming-bar which is supported in the tank and is adapted to direct said floating layer over the submerged top of said partition into the settling-chamber and toward the overflow-outlet therefrom, substantially as specified.

5. The combination of a tank having an overflow-outlet, and a vertical rotatable shaft in said tank having agitator-arms located near the bottom of the tank, with a submerged settling-chamber in said tank discharging through said overflow-outlet, the inner partition of said chamber being extended around said outlet above the surface of the liquid charge and being submerged at other points below the floating layer of concentrates, and a spiral skimming-bar secured to the shaft so as to project through said layer whereby it directs the layer of concentrates into said settling-chamber, substantially as described.

6 A separating-tank having a submerged settling-chamber at one side, and an overflow-outlet from said chamber through said side, the inner wall of said chamber being above the surface of the fluid adjacent to said outlet, but submerged at other points below the floating layer of concentrates, and a pipe discharging clean wash-water into said settling-chamber close to said outlet, substantially as specified.

7. The combination of a separating-tank containing an agitator-mechanism, with means for discharging into the contained fluid charge a gas and a liquid lighter than water and immiscible therewith, substantially as specified.

8. The combination of a separating-tank, a hollow shaft rotatably mounted therein having hollow connected agitator-arms which are provided with a plurality of discharge-openings, a pipe extending through said shaft, branch pipes connected with said pipe and extending toward the sides of the tank and having downwardly-directed discharge-openings, and means for forcing gas down through said shaft, and means for forcing a liquid down through said pipe, substantially as specified.

9. The combination of a separating-tank, a rotatable agitator-shaft therein having arms secured to it near the bottom of the tank, said arms having lifting-plows near their outer ends and inclined scrapers between said plows and the shaft substantially as described.

10. The combination of a tank, with a vertical agitator-shaft therein having a bell-shaped lower end, a pedestal which is embraced by said lower end whereby the shaft is supported, and means

for discharging water into said bell-shaped shaft end, and means for discharging a gas into said bell-shaped shaft end, substantially as specified.

11. The combination of a separating-tank having an overflow-outlet, agitating mechanism, a skimming-bar, and a pipe having jet-openings arranged over the surface of the charge in the tank to move the floating surface layer toward said overflow-outlet, substantially as specified.

In testimony whereof I hereunto affix my signature in the presence of two witnesses.

EDMUND B. KIRBY.

Witnesses:
T. L. SAVAGE.
E. G. EASTMAN.

No. 879,985. PATENTED FEB. 25, 1908.

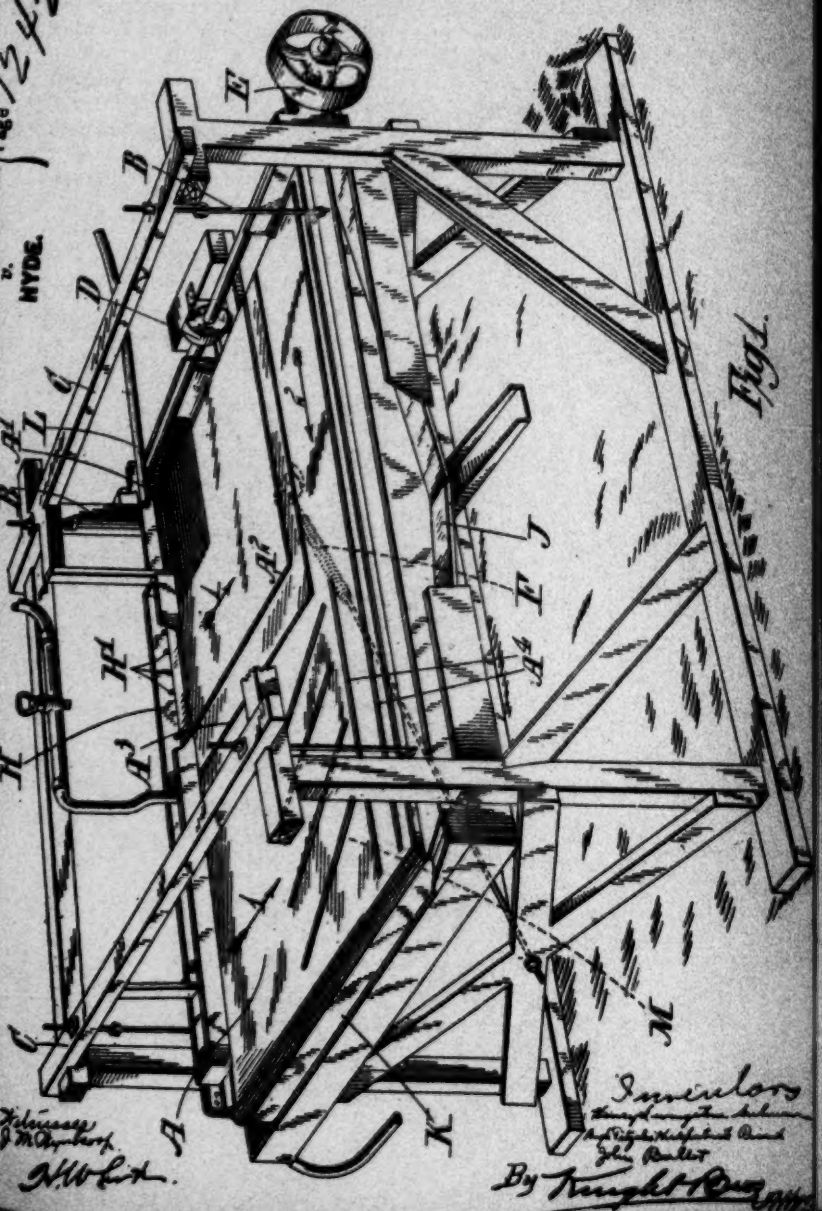
H. L. SULMAN, H. F. KIRKPATRICK-PICARD & J. BALLOT.

SEPARATION OF METALLIFEROUS MINERALS FROM GANGUE.

APPLICATION FILED FEB. 20, 1905.

4 SHEETS—SHEET 1.

No. 250 MINERALS Separation, Ltd. et al. v. HYDE. Page 1242



No. 879,985. PATENTED FEB. 25, 1908.

H. L. SULMAN, H. F. KIRKPATRICK-PICARD & J. BALLOT.

SEPARATION OF METALLIFEROUS MINERALS FROM GANGUE.

APPLICATION FILED FEB. 20, 1905.

4 SHEETS—SHEET 2.

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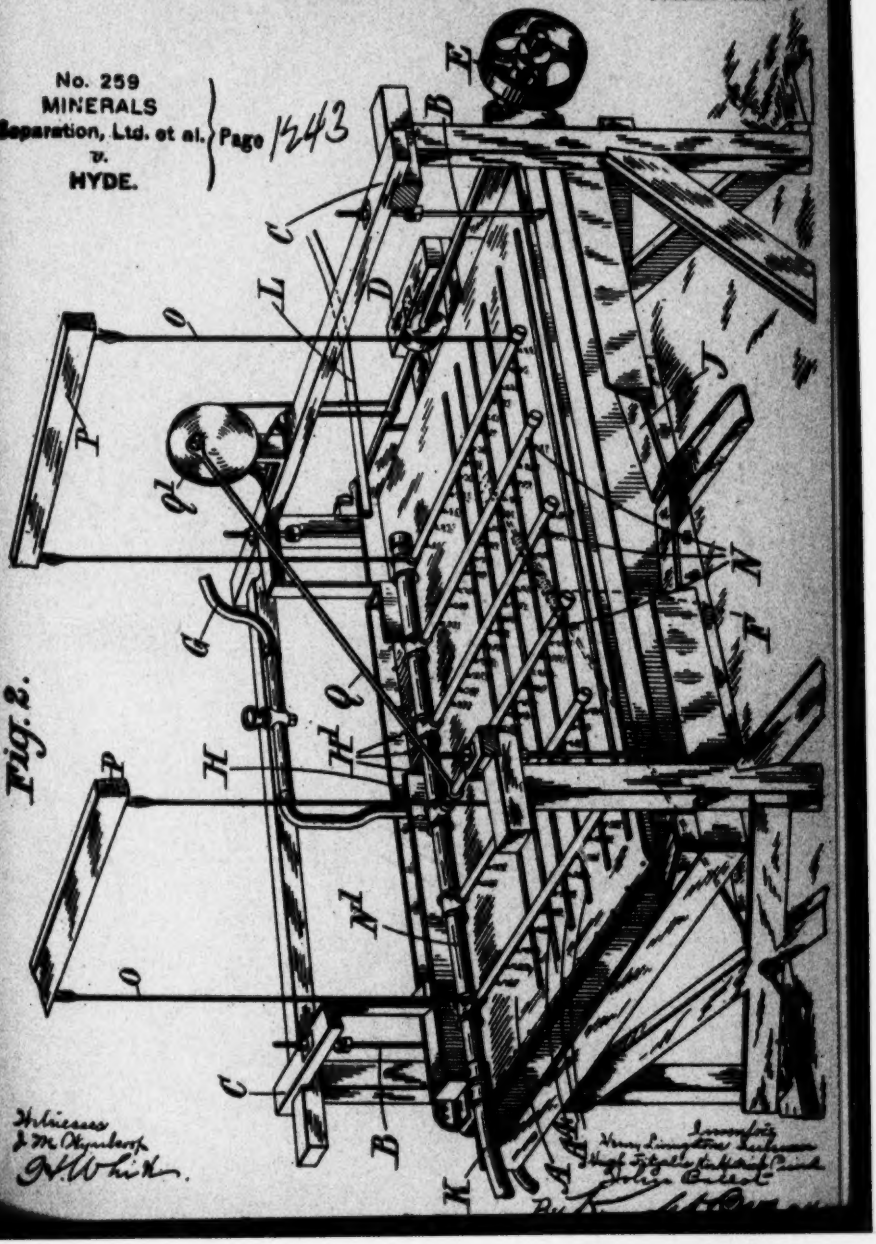

Fig. 2.

Witnesses
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H. W. Whitt.

Inventors
Henry Livingstone Sulman
Hugh Fitzalis Kirkpatrick Picard
Julius Ballot
By [illegible]

No. 879,985. PATENTED FEB. 25, 1908. 124

H. L. SULMAN, H. F. KIRKPATRICK-PICARD & J. BALLOT.

SEPARATION OF METALLIFEROUS MINERALS FROM GANGUE.

APPLICATION FILED FEB. 20, 1905.

4 SHEETS—SHEET 3.

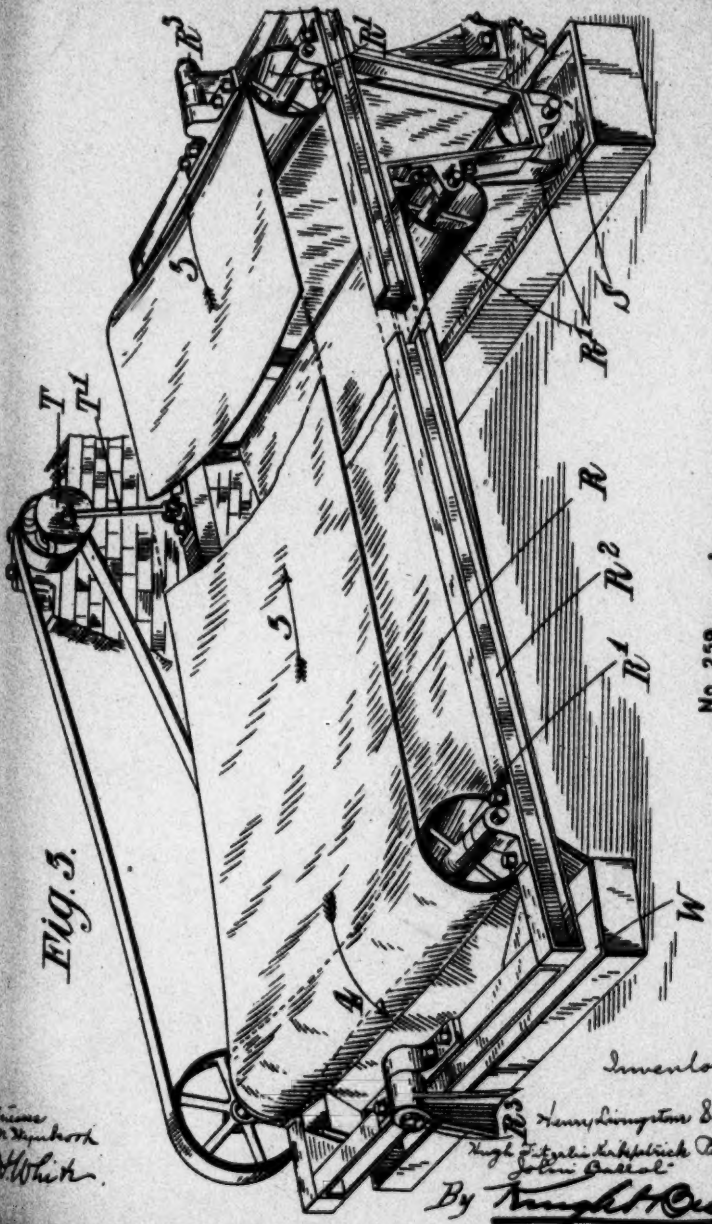

Fig. 3.

No 259
MINERALS
Separation, Ltd. et al.
v.
HYDE.
Page 1244

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No. 879,985. PATENTED FEB. 25, 1908.

H. L. SULMAN, H. F. KIRKPATRICK-PICARD & J. BALLOT.

SEPARATION OF METALLIFEROUS MINERALS FROM GANGUE.

APPLICATION FILED FEB. 20, 1905.

4 SHEETS—SHEET 4.

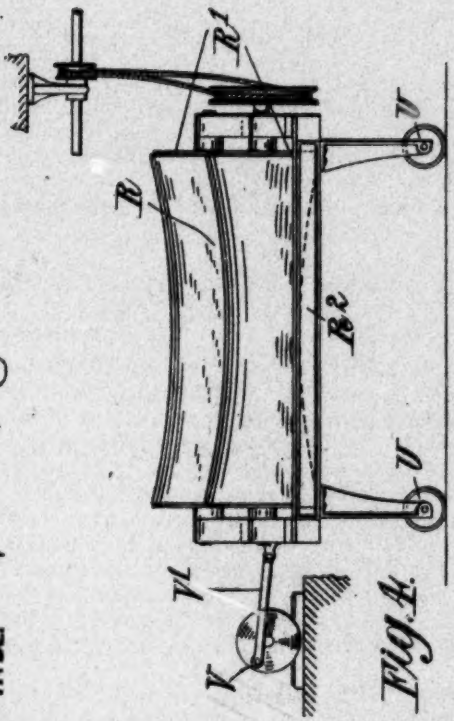

Fig. 4.

No 259
MINERALS
Separation, Ltd. et al.
v.
HYDE.
Page 1245

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1241 [DEFENDANT'S EXHIBIT DRAWINGS AND SPECIFICATION OF LETTERS PATENT NO. 879,985, PATENTED FEBRUARY 25, 1908, ISSUED TO H. L. SULMAN ET AL.]

(Here follow diagrams marked pp. 1242 to 1245.)

1246 United States Patent Office.

HENRY LIVINGSTONE SULMAN, HUGH FITZALIS KIRKPATRICK-PICARD, and JOHN BALLOT, of London, England.

Separation of Metalliferous Minerals from Gangue.

No. 879,985. Specification of Letters Patent. Patented Feb. 25, 1908.

Application Filed February 20, 1905. Serial No. 246,637.

To all whom it may concern:

Be it known that we, Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard, and John Ballot, subjects of the King of England, and residing in London, England, have invented certain new and useful Improvements in the Separation of Metalliferous Minerals from Gangue, of which the following is a specification.

This invention relates to improvements in the separation of metalliferous matter from gangue and has for its object to effect such separation by the agency of a substance which has a preferential affinity for metalliferous matter over gangue, and by the agency of air or other gas. The substance such as oil, fatty acid, or oleaginous, fatty or tarry substances which have a tendency to wet metalliferous matter in preference to gangue will hereinafter be referred to as "oil."

According to this invention the principles of surface-tension are applied in effecting the separation. The mineral pulp is mixed with "oil" and is exposed to a free air surface; and thereafter the mineral is brought on to the surface of water or other liquid, whereby the oiled metalliferous particles, having been exposed to air, are unable to overcome the surface tension of the water and float, while the unoiled gangue sinks through the surface of the water, the former being thus separated from the latter and removed by any suitable means.

In one particular application of this invention the pulp mixed with "oil" is distributed in the form of a thin sheet on the surface of an inclined vanning table having a transverse stream of water and currents of air are directed on to the table to expose immersed

mineral to a free air surface whereupon the metalliferous matter floats and is separated from the gangue which sinks.

It is known that every free water surface, i. e. a water surface in contact with air or other gas, exhibits a resistance to rupture from without greater than that which is offered by its interior mass. This phenomenon is known as the surface-tension of water and permits small particles of greater specific gravity than water to float upon it without rupturing its surface. All liquids exhibit surface tension phenomena to a greater or less degree, but the results are very marked where previously oiled particles are brought upon the surface of an aqueous liquid in which the oil or other fatty substance employed is insoluble or immiscible.

The resultant of the surface-tensions between the oiled particles and air and between that of the water and air, is so increased over that which exists between the air and water and air and unoiled particles, that oily particles of a much higher specific gravity in relation to water are unable to break through the water surface and therefore float with ease, quite apart from any slight diminution to their specific weight by means of adhering oil; whereas particles of lesser specific gravity, but unoiled, readily break through the water surface, especially if these particles be previously wetted with water.

The physical phenomena above defined are according to this invention applied as follows:—The ore in which it is desired to separate, metalliferous mineral from gangue is reduced to powder of a suitable degree of fineness, and mixed with water. To the mixture, oil or fatty substance, either in a free state or as an emulsion, is added and the whole thoroughly mixed; the water may have either an acid or alkaline reaction according to the nature of the ore to be treated. Oil or fatty substance exhibits the well known tendency to adhere preferentially to metalliferous mineral immersed or suspended in water, but does not attach itself to gangue or oxids. The amount of oil used may be comparatively small in relation to the ore pulp or to the mineral present. It is not employed in quantities sufficient to buoy up, by virtue of its lesser specific gravity, the mineral particles to which it attaches itself; but it is sufficient to use only such a quantity as will insure each mineral particle being thinly coated with a film of oil or fatty substance. The mass of oiled and unoiled particles is now brought in contact with air or other gas, either by removal of the mass from the aqueous liquid or by draining off the latter; and in order to insure sufficient air contact, the mass should be exposed in comparatively thin layers or sheets. If the particles be now brought upon or into contact with a fresh water surface, the previously specified surface-tension factors are brought into play, and it will be found that the oiled metalliferous particles can be floated off with ease and completeness from the gangue or unoiled particles, the latter sinking through the water surface.

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In the accompanying drawings:—Figures 1, 2 and 3 are perspective views of three different forms of apparatus suitable for carrying this invention into practical effect; and Fig. 4 is an end elevation of a modification of Fig. 3.

Referring to Fig. 1, an inclined vanning table A is supported by hangers B from a fixed framework C. An endwise jerking motion is imparted to the table in the direction of the arrows 2 by a cam D rotated by a driven pulley E, and a strong spring F acts in the opposite direction to the cam. A stream of water from a pipe G is distributed from a channel H perforated as at H^1 so as to flow across the table in the direction of the arrows 1. At the discharge side of the table is one launder J while a second launder K at the end of the table receives the longitudinal discharge. The mineral may be oiled in the manner before indicated or according to any of the known means, and the pulp mass is fed through a pipe L and through a suitable distributer, if required, on to the surface of the table A. Directly the oiled particles, having come into contact with air arrive on the water surface, they float for a sufficiently long period in the direction of the arrows 1 and thus permit of their separation and recovery in the launder or receptacle J; while the gangue sinks through the film of acqueous liquid and in consequence of the vanning motion imparted to the table works forward in the direction of the arrows 2 and is collected in the launder or receptacle K. In order to expose the pulp to the air as much as possible the surface of the table may be corrugated as at A^1 or a series of steps such as A^2 A^3 may be formed thereon. Or a series of raised surfaces M placed at a suitable angle to the forward travel of the submerged particles may be formed on the surface of the table, over which the submerged particles are forced to climb by virtue of the forward jerking motion, and by these means any oiled particle which may have escaped air contact is caused to come into such contact. If required guiding ribs A^4 may be attached, to direct the gangue to the launder K.

Referring now to Fig. 2, the vanning table is arranged as described with reference to Fig. 1 without the parts A^1, A^2, A^3, but if desired with longitudinal ribs A^4. Above the table is arranged a series of pipes N perforated on the under side, supported by wires or ties O from a framework P or the like. To the pipes N is attached a connecting rod Q reciprocated by a crank Q^1 so that the pipes are moved to and fro above the surface of the table. Air is led into the pipes N through an inlet tube N^1. Should any oiled mineral penetrate the water surface, it will be brought into contact with air again by the air jets blowing on the surface so as to rupture it and expose the immersed oiled particles to the air.

Referring to Fig. 3, the continuous inclined concave belt R passing over the rollers R^1 is driven upwards on the top side in the direction of the arrows 3; then it passes down through a trough S containing water. The rollers R^1 are carried in a frame R^2 pivoted at R^3 about the longitudinal axis and the frame is rocked about its pivot by a crank T and connecting rod T^1. Or as shown in Fig. 4 the frame may be mounted on rollers U and lateral reciprocating motion imparted to the frame by a crank V and connecting rod V^1. The pulp is fed on to the top of the moving belt and a certain proportion of oiled mineral floats, and is carried downward by the stream into the launder W in the direction of the arrow 4; while

the unoiled particles sink and are carried up by the belt in the direction of the arrows 3, and discharged into the trough S. As the belt rocks or reciprocates, the liquid moves from side to side, and at each movement leaves some mineral freely exposed to the air on the side of the belt. Thus, any immersed oiled particles become exposed to a free air surface and on the return of the liquid are floated off and carried down into the launder W. The inclination of the belt must be so regulated that no sands are mechanically carried off with the concentrates.

Any apparatus suitable for the separation of floating from immersed solid particles may be used to effect the separation according to this invention. The water used to form the water surface may conveniently be slightly acid or in certain cases slightly alkaline, provided that the alkalinity is not sufficient to affect the surface-tension.

The flotation power exerted in the method above described is so considerable that aggregations of heavy oiled mineral particles may be observed floating upon the surface of the water, (more or less self-adherent) and exhibiting a concave or boat-like formation upon the surface of the water, due to the great specific gravity of the mineral particles which in consequence of their oiled surfaces are yet unable to break through the water surface.

We are aware that gases have been used previously for the separation of oiled mineral particles from unoiled particles when immersed beneath the surface of an aqueous liquid. This has been effected by the attachment of gas bubbles (preferably generated in the liquid i. e. in an acid condition) whereby the mineral particles are raised to the surface by means of the buoyancy of the gas bubbles adhering to the particles. It is to be clearly understood that our method of separation does not take place beneath
1248 the water surface but depends solely on the flotation of previously oiled particles which have been brought into contact with air or other gas and then introduced upon the water surface.

What we claim as our invention and desire to secure by Letters Patent is:—

1. The process of treating ores to separate metalliferous matter from gangue which consists in mixing the powdered mineral with water to form a freely flowing pulp, agitating the mineral pulp with a small quantity of oil sufficient only to impart a thin coating of oil to the metalliferous particles, distributing the mixture in the form of a thin sheet of flowing liquid, causing the immersed particles to be exposed to the air and thereafter to meet the surface of the liquid, collecting the floating oiled metalliferous particles and collecting the gangue which sinks.

2. The process of treating ores to separate metalliferous matter from gangue which consists in mixing the powdered mineral with water to form a freely flowing pulp, agitating the mineral pulp with a small quantity of oil sufficient only to impart a thin coating of oil to the metalliferous particles distributing the mixture in the form of a thin sheet of flowing liquid, directing currents of air on to the liquid to expose the immersed mineral to the air,

whereby the oil-coated metalliferous particles float, collecting the floating oiled metalliferous particles and collecting the gangue which sinks.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

HENRY LIVINGSTONE SULMAN.
HUGH FITZALIS KIRKPATRICK-PICARD.
JOHN BALLOT.

Witnesses:

WILLIAM H. BALLANTYNE,
W. W. WEBSTER.

1249 [DEFENDANT'S EXHIBIT DRAWING AND SPECIFICATION OF LETTERS PATENT NO. 1,022,085, PATENTED APRIL 2, 1912, ISSUED TO JAMES M. HYDE.]

(Here follows diagram marked p. 1250.)

1251 United States Patent Office.

JAMES M. HYDE, of Basin, Montana.

Art of Concentration of Mineral Substances.

1,022,085. Specification of Letters Patent. Patented Apr. 2, 1912.

Application Filed November 10, 1911. Serial No. 659,583.

To all whom it may concern:

Be it known that I, James M. Hyde, a citizen of the United States, residing at Basin, in the county of Jefferson and State of Montana, have invented certain new and useful Improvements in the Art of Concentration of Mineral Substances, of which the following is a specification.

My invention relates to the separation by a flotation process of a part of the mineral substances composing an ore consisting of a plurality of mineral components.

It has heretofore been demonstrated that certain metallic and non-metallic elements, and certain natural chemical compounds of the metallic elements differ from the ordinary less valuable or valueless gangue minerals with which they occur in ore deposits, in that under certain conditions they are preferentially coated by oils, fats, oleaginous and fatty substances and derivatives thereof, and certain other organic compounds, and that when so coated they exhibit markedly different surface tension phenomena from, and can by various devices and methods be separated from, the gangue minerals, and, in certain instances at least, to a certain extent from one another.

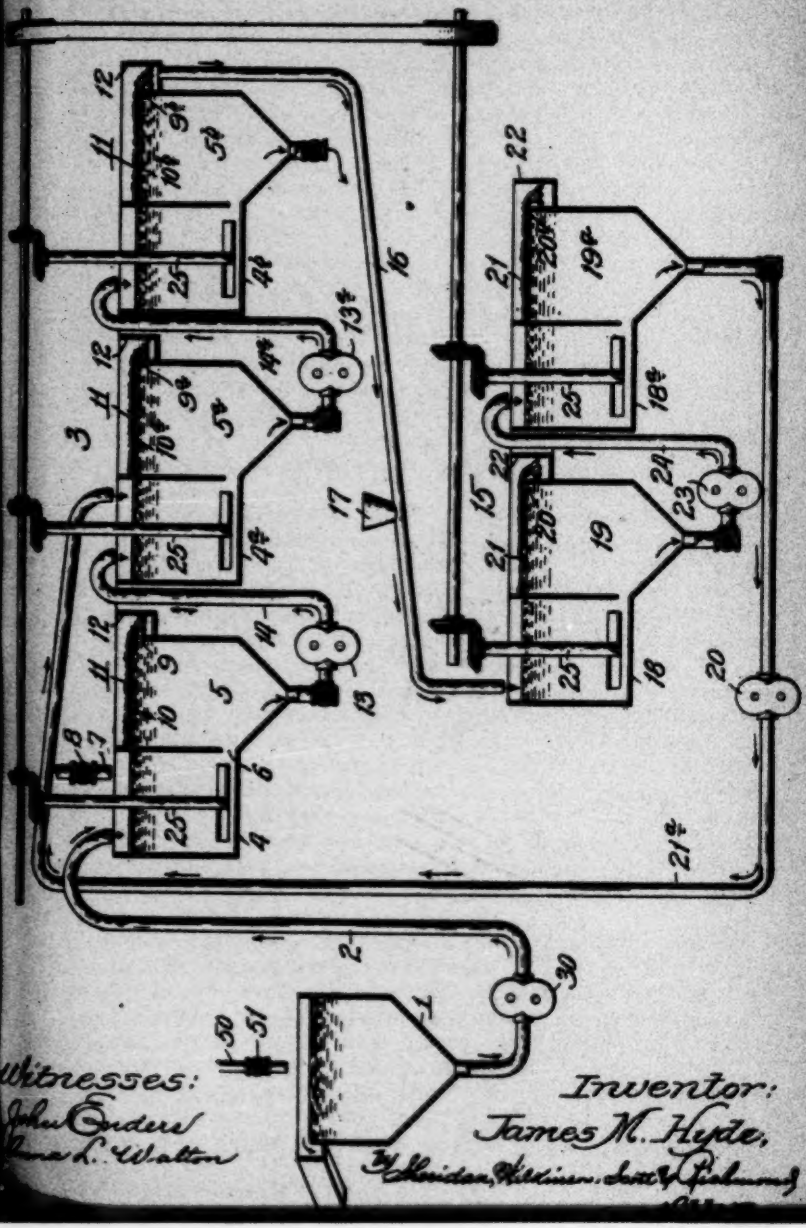
Many ores containing a plurality of mineral components are of such a nature that when they are crushed a considerable amount of the resultant pulverized material consists of particles which are so fine and of such a colloidal nature that they settle very slowly and interfere with obtaining a high grade concentrate by the use of a flotation process. In the treatment of ores of this class I have found that their treatment is greatly facilitated, and a considerable economy is effected, by introducing a small amount of sulfuric acid with or without copperas, alum or some other such coagulant, into the pulp

J. M. HYDE.

ART OF CONCENTRATION OF MINERAL SUBSTANCES.

APPLICATION FILED NOV. 10, 1911.

1,022,085. Patented Apr. 2, 1912.



Witnesses:
John Enders
Anna L. Walton

Inventor:
James M. Hyde,
By Sheridan, Wildman, Scott & Richmond
Attys.

while in transit to the flotation device, instead of by using a larger amount of acid in the flotation device as has been done in previous practice. The acid apparently performs the following, among other functions:—the partial or complete coagulation of the slimes so that they settle much more quickly, thus making possible the thickening of the pulp in an intermittent or continuously acting pulp thickener, by the removal of a considerable amount of clear water or water containing a lessened amount of suspended solid matter, and also greatly facilitating the separation of the concentrates from the gangue in the flotation machine; the cleaning of the surface of the particles of the floatable minerals, so that they may be more readily coated by the chosen coating reagent; the generation of minute bubbles of gas in the pulp and on the surface of the floatable mineral particles, which bubbles assist in the desired separation of the mineral components of the ore; and in neutralizing any alkalinity of the ore or treatment water. The addition of the acid to the pulp before it reaches the flotation machine, rather than in the machine as has heretofore been done, affords a longer period of contact with the ore and greatly reduces the amount of acid which it is necessary to use. It precludes the necessity of having the pulp show any free acid when the flotation treatment takes place. By following this method, I have been able to get highly satisfactory results when using as little as one quarter of a pound of crude acid per ton of ore treated, whereas in previously used methods, several pounds have been found necessary.

I have further discovered that the concentrates produced, when the acid is used substantially as hereinbefore described may be retreated and raised in grade, when they contain free particles of the gangue matter, by being put through a treatment similar to that by which they were made, and that this retreatment can, in certain cases at least, be satisfactorily made without the use of additional amount of acid or coating reagent in the "cleaner machine."

Any fats or oils, fatty or oleaginous substances or derivatives thereof, and any other organic compounds which preferentially coat mineral substances may be used in this process for the coating of such mineral particles as can be made to float on the surface of water for any of the following reasons:—because of the lower specific gravity of the oily or fatty substances to which they are attached, because of their tendency to form a film on the surface of the water when properly coated, or because of their tendency to attach themselves to and be raised by bubbles of any gas which may be generated in, or introduced into the pulp.

A suitable apparatus for carrying out this process consists of launders or pipes, used in connection with or without pulp
1252 thickeners, and a combination of mixing boxes and spitzkastens, or overflow separating devices. Any one of a number of devices now in use, or any simple and apparent modification thereof may be made use of for this purpose.

In the drawing I have diagrammatically illustrated an apparatus whereby my process can be conveniently practiced.

Acid is added to the pulp in or prior to reaching the pulp thick-

ener 1, which is used if the prior treatment of the ore has given rise to a pulp containing more water than is suitable for the practice of my process. The acid whether added to the pulp in the thickener or before reaching the thickener is supplied through means under the control of the operator, such as the pipe 50 leading from the acid supply, which pipe is provided with a hand valve 51. The pulp thickener may consist of any of the ordinary devices used for that purpose, such as pointed boxes having provision for overflow of the clear water. The thickened pulp is drawn off from the bottom of the thickener 1 and the waste water allowed to flow from the top thereof. The thickened pulp is conducted from the thickener 1 through the pipe or launder 2 to the flotation machine designated generally by the numeral 3, a pump 30 being used for this purpose, if necessary. The flotation machine as illustrated consists of three agitator tanks 4, 4^a and 4^b, and three settlement boxes 5, 5^a and 5^b. Each of the agitator tanks may, if necessary, consist of a plurality of connected compartments each provided with an agitator. The agitator tank 4 is connected near its lower end at 6 with the settlement box 5, the agitator tank 4 and settlement box 5 constituting the first unit of the flotation or separation apparatus. The other two units consist respectively of the agitator tank 4^a with its settlement box 5^a and the agitator tank 4^b with its settlement box 5^b. The three units are of similar construction. The pulp is first received in the agitator tank 4 and thoroughly agitated with oil from the pipe 7, which is provided with a hand valve 8 under the control of the operator. The pulp flows continuously through the machine, its rate of flow being regulated in such manner as to produce the best results. After agitation in the tank 4 the pulp passes through the passage 6 into the settlement tank 5. The sulfid particles having become coated with oil in the agitator tank 4 rise to the surface of the settlement tank 5 in the form of a froth or scum. The level of the pulp in the apparatus is so regulated by means of suitable valves that at the overflow lips 9, 9^a and 9^b of the settlement boxes 5, 5^a and 5^b the lower surface 10 of the froth 11 is sufficiently above the lip to insure the overflow of all of the froth 11 into the launder 12. This arrangement permits more or less water to pass over with the froth into the launder 12. The partially treated pulp, still containing more or less of the sulfids or other ore values, is drawn off from the bottom of the settlement box 5 and by means of a pump 13 is forced through the pipe 14 and discharged into the agitator tank 4^a of the second unit of the flotation machine. The apparatus is preferably so arranged that the pulp stands at the same level in the different units of the flotation device, and in the second unit of the cleaner machine which is described below, in which event the pumps are not necessary to lift the pulp but merely serve to assist in its movement. The arrangement of the apparatus may, however, be varied when necessary or desirable. In this unit the same operation takes place as in the first unit, namely, agitation in the tank 4^a, overflow of froth with more or less water from the settlement box 5^a into the launder 12 and discharge of the pulp from the bottom of the settlement box 5^a. From the bottom of the settlement box 5^a the pulp is forced by

means of a pump 13ª through pipe 14ª and discharged into the agitator tank 4ᵇ of the third unit where the pulp is agitated and discharged into the settlement box 5ᵇ where the froth with some water is drawn off into the launder 12. The pulp after treatment in the third unit is discharged from the bottom of the settlement box 5ᵇ as tailings or waste, the treatment above described in the three units of the flotation machine having practically exhausted the ore of its valuable parts. In practice I have attained by the treatment described a separation running as high as 95% of the sulfids.

In conducting my process the operator constantly observes the condition of the material in the agitator tanks and on the surface of the settlement boxes 5, 5ª and 5ᵇ of the flotation machine, and likewise observes the condition of the tailings being discharged from the machine. By such observation the operator is enabled to determine whether the sulfids or other ore values are being properly separated from the gangue. The appearance of flocculent masses of sulfids in the tailings indicates the use of too large an amount of oil, while the appearance of finely divided sulfids in the tailings indicates the use of too little oil. Other indications are apparent to an operator after a little experience and by properly manipulating the valve 8 which regulates the oil supply he is able to control the operation in such manner as to secure a maximum recovery, equal, as above stated, in some cases to 95% of the entire value contained in the ore.

The launder or pipe 12 receives the sulfids, together with some water and gangue from all three units of the flotation ma-
1253 chine 3 and these sulfids are conducted from the launder 12 to the cleaner machine which is designated generally by the numeral 15. In transit from the flotation machine to the cleaner machine the froth is conducted through a launder or pipe 16 and more water is supplied thereto, if necessary, through a pipe 17. The concentrates thus diluted are discharged into the agitator tank 18 of the cleaning apparatus and are there agitated with or without the addition of further oil, acid or other chemicals as may be desirable. From the agitator box 18 the concentrates with the water carrying them are conducted to the settlement box 19. The froth obtained in the primary or flotation machine 3 contains more or less gangue which is entrapped in the froth, and it is to purify the concentrates that I employ the secondary or cleaner machine 15. The agitation of the concentrates in the secondary machine has the effect of breaking them up to a considerable extent thereby causing the entrapped gangue to become separated from the oil coated concentrates. After agitation of the concentrates in the tank 18, as above stated, the concentrates, together with the water added thereto, are conducted to the settlement box 19, in which the gangue which has been freed from the concentrates settles to the bottom with a certain amount of the sulfids. The level of the material in the cleaning machine 15 is so regulated by means of suitable valves that the overflow lips 20 and 20ª of the settlement boxes 19 and 19ª extend slightly above the lower surface of the froth 21, the purpose being

to prevent any escape of free flowing water with the froth 21 into the launder 22. As a result of this arrangement some of the froth and all of the slime carrying water will be prevented from overflowing into the launder 22 and will be carried down to the bottom of the settlement box 19. From the bottom of the settlement box 19 the water carrying with it such gangue as has been freed from the froth and also carrying such of the sulfids as have failed to flow over the lip 20 is forced by the pump 23 through the pipe 24 and discharged into the second agitator tank 18^a of the cleaning machine. The operation in the second unit of the cleaning machine is precisely the same as that described in the first unit, the overflow at the lip 20^a being adjusted as described in connection with the first unit to prevent foul water from overflowing into the launder 22. The discharge from the bottom of the settlement box 19^a will therefore contain not only such of the gangue as has been freed from the oil-coated sulfids, but will also contain a small amount of the sulfids. The discharge from the bottom of the second settlement box 19^a of the cleaner machine is therefore forced by pump 20 or otherwise conducted through pipe 21^a and discharged into the agitator tank 4 or 4^a of the flotation machine and carried through the rest of the apparatus, together with the fresh pulp.

By the means above described, I remove a large portion of the impurities from the concentrates formed in the flotation machine, and by conducting the material drawn off from the bottom of the settlement tank 19^a of the cleaner machine and retreating the same in the primary or flotation machine I effectually guard against any loss of concentrates in the cleaning operation. The agitators 25 shown in the agitator tanks of the flotation and cleaning machines may be of any preferred form and rotated by any means available.

As an example of the way in which these improvements may be used the following description is given of the treatment of a parcel of ore by this method. The material treated was the slimy portion of an ore consisting principally of quartz, blende (the sulfid of zinc) and varying amounts of decomposed granite in which the feldspars were largely kaolinized. About 92% of this material was fine enough to pass through a 150 mesh screen. Unless a coagulant were used a portion of the slime containing a valuable amount of zinc would remain in suspension for over 24 hours. The pulp as produced contained from 20 to 100 or more parts of water by weight to one part of ore, whereas the ratio should have been from two and one half to one to four to one. To this pulp while in transit to the thickeners, was added an amount of commercial sulfuric acid equivalent to from one quarter to one half pound per ton of ore treated. At times a decided odor of hydrogen sulfid could be noticed around the pulp thickeners. The thickened pulp, usually showing no free acidity, was led to the flotation machine in which it was heated by live steam to enlarge and expand the gas bubbles generated by the acid and to facilitate the coating of the sulfid particles with the coating reagent which was added in the flotation machine. The amount of oil necessary to produce the proper result cannot be determined in advance owing to variations in the rate of flow of pulp through the

apparatus, differences in the degree of dilution of the pulp, i. e. differences in the amount of ore carried by the water, and variations in the composition of the ore, the ore sometimes running much higher in sulfids than at other times. There may also be other factors which have an effect upon the quantity of oil necessary to float the maximum percentage of the sulfids or other ore values. At any rate, I have found in practice that the only efficient mode of carrying out the process is to constantly observe the results
1254 produced and to vary the supply of oil accordingly. The flotation or separation machine used in the test was of a character similar to that illustrated and described above. The pulp was thoroughly agitated to insure the coating of all of the sulfid particles with the proportionately very small amount of "candle maker's red oil" which was used as the coating agent.

After treatment in the three units of the separation machine the gangue matter as tailings was run to waste from the bottom of the settlement box of the third unit. The concentrates which had overflowed from the three settlement boxes of the primary machine were collected in the same launder and conducted to the secondary or cleaner machine, and in the cleaner machine the concentrates were treated without further addition of oil or acid. From the cleaner machine high grade concentrates were collected and rich tailings were returned to the second unit of the primary machine for retreatment. In this test run the ore fed contained 23.3% zinc, the concentrates 51.4% zinc, and the tailings 3.2% zinc, giving an indicated recovery of 91% of the zinc in the ore treated. These results were in large part due to the method of using the acid and retreating the concentrates made in the primary machine, which concentrates contained but from 38% to 42% of zinc before retreatment.

It will be understood that the apparatus diagrammatically illustrated in the drawing may be varied in form, the illustration and description of the apparatus referred to being introduced merely for the purpose of clearly setting forth the several steps of my process.

I claim:

1. The process of concentrating ore pulps comprising a separation treatment which consists in adding to the pulp a material which preferentially coats the valuable particles of the ore, agitating the mixture, permitting the valuable parts of the ore to float in the form of a froth, separating the froth by overflowing it together with some of the water in order to insure overflow of the entire mass of the froth, subjecting the separated froth to a cleaning treatment which consists in reagitating the concentrated material to free impurities entrapped therewith, permitting the concentrates to again form a froth and allowing the impurities to settle, overflowing the froth without any free flowing water, and returning the settled impurities and the part of the froth not carried into the overflow to the part of the pulp which is undergoing the separation treatment.

2. A continuous process of concentrating the valuable constituents from ore pulps comprising the addition to the pulp of an acid precipitant adapted to react upon the ore, allowing a time interval to

elapse prior to subjecting it to the separation treatment, then subjecting the pulp to a separation treatment comprising the steps of adding a material which will preferentially coat the valuable particles of the ore and separating said coated particles as a concentrate by flotation.

3. A continuous process of concentrating the valuable constituents from ore pulps comprising the addition to the pulp of an acid precipitant adapted to react upon the ore, allowing a time interval to elapse prior to subjecting it to the separation treatment, then subjecting the pulp to a separation treatment comprising the steps of adding a non-metallic material which will preferentially coat the valuable particles of the ore and separating said coated particles as a concentrate.

4. A continuous process of concentrating the valuable constituents from ore pulps comprising the addition of an acid precipitant to the pulp, allowing a time interval to elapse prior to subjecting it to the separation treatment, then subjecting the pulp to a separation treatment comprising the steps of adding a material which will preferentially coat the valuable particles of the ore and separating said coated particles as a concentrate by flotation, subjecting the concentrate thus produced to a cleaning treatment which consists in agitating the concentrated material, permitting the concentrates to float, removing the concentrates from the top of the mixture, and returning the material which settles after the cleaning agitation to the part of the pulp which has passed through the first two steps specified and which is undergoing the separation treatment.

5. A continuous process of concentrating the valuable constituents from ore pulps comprising the addition of an acid precipitant to the pulp, allowing a time interval to elapse prior to subjecting it to the separation treatment, then subjecting the pulp to a separation treatment comprising the steps of adding a material which will preferentially coat the valuable particles of the ore and separating said coated particles as a concentrate, subjecting the concentrate thus produced to a cleaning treatment which consists in agitating the concentrated material, removing the concentrates from the mixture, and returning the rest of the mixture to the part of the pulp which has passed through the first two steps specified and which is undergoing the separation treatment.

6. A continuous process of thickening and concentrating ore pulps comprising the addition to the thin pulp of an acid precipitant adapted to react upon the ore and producing a thickened pulp by separating water, then subjecting the thickened pulp to a separation treatment comprising the steps of adding a material which will preferentially coat the valuable particles of the ore, and separating said coated particles as a concentrate by flotation.

1255 & 1256

7. A continuous process of thickening and concentrating ore pulps comprising the addition of an acid precipitant to the thin pulp, producing a thickened pulp by separating water, then subjecting the thickened pulp to a separation treatment comprising the steps of adding a material which will preferentially coat the valuable

particles of the ore, and separating said coated particles as a concentrate by flotation, subjecting the concentrates thus produced to a cleaning treatment which consists in agitating the concentrated material, permitting the concentrates to float, removing the concentrates from the top of the mixture, and returning the material which settles after the cleaning agitation to the part of the pulp which is undergoing the separation treatment after the thickening step.

8. The process of concentrating ore pulps comprising a separation treatment which consists in adding to the pulp a material which preferentially coats the valuable particles of the ore, agitating the mixture, permitting the valuable particles of ore to float in the form of a froth, separating the froth with some of the water in order to insure separation of the entire mass of the froth, subjecting the separated froth to a cleaning treatment which consists in reagitating the concentrated material to free impurities entrapped therewith, permitting the concentrates to again form a froth and allowing the impurities to settle, removing the froth without water, and returning the settled impurities and the part of the froth not removed to the part of the pulp which is undergoing the separation treatment.

9. The process of concentrating ore pulps comprising a separation treatment which consists in adding to the pulp a material which preferentially coats the valuable particles of the ore, agitating the mixture to bring the coating material into contact with all of the particles which can be made to float, separating the floating coated material as a concentrate with some of the water thereby insuring removal of all of the floating material, subjecting this separated material to a cleaning treatment to permit the impurities remaining therewith to settle and refloating the concentrates, removing the upper purest part of the cleaned concentrates and returning the impurities and the remaining part of the concentrates to the part of the pulp which is undergoing the initial flotation treatment prior to the cleaning operation.

10. The process of concentrating ores which consists in adding to the ore a material which preferentially coats the valuable particles of the ore, separating said coated valuable particles from the gangue by floating said coated valuable particles on water, separating the floating coated particles as a concentrate with some of the water thereby insuring removal of all of the floating valuable particles, subjecting this separated material to a cleaning treatment to permit the impurities remaining therewith to settle and refloating the concentrates, removing the upper purest part of the cleaned concentrates, and returning the impurities and the remaining part of the concentrates to the part of the ore which is undergoing the initial flotation treatment prior to the cleaning operation.

In testimony whereof, I have subscribed my name.

JAMES M. HYDE.

Witnesses:
J. BRUCE KREMER.
WALTER A. SCOTT.

1257 [DEFENDANT'S EXHIBIT SPECIFICATION OF LETTERS PATENT No. 12,778, ACCEPTED JUNE 4, 1903, ISSUED TO HENRY HARRIS LAKE.]

1258 [British Coat of Arms.]

No. 12,778. A. D. 1902.

Date of Application, 4th June, 1902.

Complete Specification Left 4th Mar., 1903; Accepted 4th June, 1903.

Provisional Specification.

Communicated by ALCIDE FROMENT, of Traversella, in the Kingdom of Italy, Engineer.

"Improvements Relating to the Concentration of Ores."

I, Henry Harris Lake, of the firm of Haseltine, Lake & Co., Patent Agents, 45, Southampton Building, in the County of Middlesex, do hereby declare the nature of this invention to be as follows:—

The following phenomena, studied by the inventor, have served as the basis of the process which forms the subject of this invention.

1. When the natural sulphides reduced to powder are moistened by a fatty substance, they have a tendency to unite in spherules and to float upon a surface of water.

2. This tendency is simply retarded by the specific weight, and opposed by the gangue which imprisons the moistened sulphides in its pulverulent mass.

3. If a gas of any kind is liberated in this mass, the bubbles of the gas become covered with an envelope of sulphides and thus rise readily to the surface of the liquid where they form a kind of metallic magma.

3. The formation of these metallic spherules is singularly active if the gas is in a nascent state.

Thus for example, if in a test tube there is placed say ten grammes of sulphuretted copper ore with its gangue, a gram of limestone, the whole reduced to powder, and if there is added thereto thirty grammes of water, a few drops of sulphuric acid and a thin layer of ordinary oil, and the mixture then agitated for a brief space, the whole of the chalcopyrite will instantly rise to the top of the liquid. The metallic spherules, pressed one against the other, will become grouped in a magma clearly separated from the rest of the liquid. If the limestone is in excess or readily attackable, the rapidity of the separation is so great that the chalcopyrite is forcibly projected outside the vessel. There is therefore a proportion to be sought for a given ore and limestone.

The small quantity of gangue mechanically conveyed gradually

falls and the sulphides remain in a state of almost compl[illegible] purity. Such is the principle.

Thus the rapidity of the formation of the spherules and their ascension is in direct ratio to the quantity of gas produced in a given time.

Example 1.

A cuprous ore containing 12% of chalcopyrite, 15% of iron pyrite, 20% of carbonate of iron, 16% of dolomite and calcite and 37% of the various gangues *have* been submitted to my said process. It should be stated that this ore could not be enriched economically by any known means.

Only a few seconds were necessary for completely separating the sulphide of copper from the rest of the gangue in which no single trace of copper could be discovered by analysis.

Example 2.

A calcitous ore having 10% of lead and unmarketable
1259 with such a proportion, has been treated in the same manner and with the same success. There are several operations which are distinct but which are connected in carrying the process into practice; the formation of the spherules and their separation from the gangue, then separation of the product of the concentration from the oil and recovery of this latter for readmission to the cycle of operations. The products of the concentration form cakes.

Dated this 4th day of June 1902.

HASELTINE, LAKE & CO.,
45 *Southampton Buildings, London,*
W. C., Agents for the Applicant.

Complete Specification.

"Improvements Relating to the Concentration of Ores."

I, Henry Harris Lake, of the Firm of Haseltine, Lake & Co., Patent Agents, 45, Southampton Buildings, in the County of Middlesex, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention has reference to the concentration of metalliferous ores and earths for the purpose of separating and recovering therefrom the finely divided metal or metallic compounds, and consists of a modification of what is known as the oiling process of ore concentration.

The following phenomena, studied by the inventor, have served as the basis of the process which forms the subject of this invention.

1. When the natural sulphides reduced to powder are moistened by a fatty substance, they have a tendency to unite in spherules and to float upon the surface of water.

2. This tendency is simply retarded by the specific weight and opposed by the gangue which imprisons the moistened sulphides in its pulverulent mass.

3. If a gas of any kind is liberated in this mass, the bubbles of the gas become covered with an envelope of sulphides and thus rise readily to the surface of the liquid where they form a kind of metallic magma.

4. The formation of these metallic spherules is singularly active if the gas is in a nascent state.

Thus for example, if in a test tube there is placed say ten grammes of sulphuretted copper ore with its gangue, a gram of limestone, the whole reduced to powder, and if there is added thereto thirty grammes of water, a few drops of sulphuric acid and a thin layer of ordinary oil, and the mixture then agitated for a brief space, the whole of the copperpyrite will instantly rise to the top of the liquid. The metallic spherules, pressed one against the other, will become grouped in a magma clearly separated from the rest of the liquid. If the limestone is in excess, or readily attackable, the rapidity of the separation is so great that the copperpyrite is forcibly projected outside the vessel. There is therefore a proportion to be sought for a given ore and limestone.

The small quantity of gangue mechanically conveyed gradually falls and the sulphides remain in a state of almost complete purity. Such is the principle.

Thus, the rapidity of the formation of the spherules and their ascension is in direct ratio to the quantity of gas produced in a given time.

Example 1.

1260 A cuprous ore containing 12% of copperpyrite, 15% of iron pyrite, 20% of carbonate of iron, 16% of dolomite and calcite and 37% of various gangues *have* been submitted to my said process. It should be stated that this ore could not be enriched economically by any known means.

Only a few seconds were necessary for completely separating the sulphide of copper from the rest of the gangue in which no single trace of copper could be discovered by analysis.

Example 2.

An ore having 10% of lead and unmarketable with such a proportion, has been treated in the same manner and with the same success. There are several operations which are distinct but which are connected in carrying the process into practice; the formation of the spherules and their separation from the gangue, then separation of the product of the concentration from the oil and recovery of this latter for readmission to the cycle of operations. The products of the concentration form cakes.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, as communicated to me by my foreign correspondent, I declare that what I claim is:—

The herein described process for the concentration of metalliferous ores and earths which consists in mixing the finely powdered ore or earth with water, adding a suitable oil and then liberating a gas in the mixture substantially as described and for the purpose specified.

Dated this 4th day of March 1903.

HASELTINE, LAKE & CO.,
45 *Southampton Buildings, London,*
W. C., Agents for the Applicant.

1261 [*Certificate of Clerk U. S. District Court to Transcript of Record, etc.*]

In the District Court of the United States for the District of Montana.

UNITED STATES OF AMERICA,
District of Montana, ss:

I, George W. Sproule, Clerk of the United States District Court for the District of Montana, do hereby certify and return to the Honorable, the United States Circuit Court of Appeals for the Ninth Circuit, that the foregoing three volumes, consisting of 1121 pages, numbered consecutively from 1 to 1121, is a true and correct transcript of the pleadings, records, orders, Decree, opinion, writ of injunction, condensed statement of evidence, exhibits, certificate of approval and other proceedings had in said cause and of the whole thereof, as appear from the original records and files of said court in my possession; and I do further certify and return that I have annexed to said transcript, and included within said paging, the original citation. I further certify that all mechanical and physical exhibits have been taken by complainant- to be produced in court when needed. I further certify that the cost of the transcript of record amounts to the sum of $198.05, and that the same has been paid by the appellant.

In witness whereof, I have hereunto set my hand and affixed the seal of said court, at Butte, in the District of Montana, this 22d day of November, in the year of our Lord one thousand nine hun-
1262 dred and thirteen and of the Independence of the United States the one hundred and thirty-eight-.

[SEAL.] GEO. W. SPROULE, *Clerk.*

(1121)

[Endorsed:] No. 2346. United States Circuit Court of Appeals for the Ninth Circuit. James M. Hyde, Appellant, vs. Minerals Separation, Limited, and Minerals Separation American Syndicate, Limited, Appellees. Transcript of Record. Upon Appeal from the United States District Court for the District of Montana.

Received and filed December 1, 1913.

FRANK D. MONCKTON,
Clerk of the United States Circuit Court
of Appeals for the Ninth Circuit,
By MEREDITH SAWYER,
Deputy Clerk.

In the United States Circuit Court of Appeals, Ninth Circuit.

No. —.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,

vs.

JAMES M. HYDE, Defendant.

Petition for Order Extending Time for Filing Record.

To the Honorable Judges of the United — Circuit Court of Appeals of the Ninth Circuit:

Your petitioner, James M. Hyde, by and through his counsel, does petition and request the above-styled court to make an order extending the time for the filing of the record on appeal in the above case for sixty (60) days, to wit, until the 8th day of December, 1913.

Your petitioner respectfully recites that the record in the above case is a large and voluminous one, to wit: comprising approximately 3,500 pages. Your petitioner further recites that under the equity rules now in force a narrated statement has been prepared and notice given by the defendant in the action to the complainants in the above case, advising them of the filing of said narrated statement and requesting them to file their amendments, if any, within the time prescribed by the rules.

Your petitioner recites that counsel for the complainants in the case below requested counsel for the defendant in the case below to extend the time in which the complainants must necessarily file their amendments, if any, to the narrated statement, and that at the request of counsel for the complainants, counsel for the defendant stipulated that the complainants might have until November 3d, 1913, in which to so prepare their amendments, on which date it is stipulated that the record might be presented to the court
1264 below for approval in accordance with the rules.

Your petitioner recites that in view of the volume of the record and the technical character thereof, this being an action based upon the alleged infringement of certain letters patent of the United States, a greater length of time is necessary to examine the narrated statement heretofore filed in the court below.

Your petitioner further recites that his counsel have received from the Clerk of the United States District Court, for the District of Montana, a letter setting forth in substance the impossibility of filing the record in accordance with the rules and citation and requesting that application be made for this additional time; the original of said letter is hereto annexed and marked Exhibit "A."

Wherefore your petitioner, in view of the foregoing, prays this Honorable Court to make an order extending the time for the filing

of the record on appeal in the above-styled case to and including the 8th day of December, 1913.

SHERIDAN, WILKINSON, SCOTT & RICHMOND,
KREMER, SANDERS & KREMER,
Solicitors for Petitioner.

STATE OF MONTANA,
County of Silver Bow, ss:

J. Bruce Kremer, being first duly sworn on oath, deposes and says:

That he is one of the solicitors and of counsel for the defendant in the above-entitled action; that he is more familiar with
1265 the existing state of the record in the above-styled case than is the defendant; that the defendant is absent from the State of Montana, wherein this affiant doth reside, and for the foregoing reasons he makes this verification for and on behalf of the above-named defendant, and states that he has read the foregoing petition and knows the contents thereof, and that the matters and things therein stated are true of his own knowledge.

J. BRUCE KREMER.

Subscribed and sworn to before me this 3d day of October, 1913.

[SEAL.] E. F. O'FLYNN,
Notary Public in and for the State of Montana,
Residing at Butte, Montana.

My commission expires May 16, 1914.

Office of Clerk U. S. District Court, Helena, District of Montana.

MISSOULA, MONTANA, Oct. 1st, 1913.

Messrs. Kremer, Sanders & Kremer, Butte, Montana.

DEAR SIRS: A citation having been issued Sept. 8, 1913, which requires a return of Transcript of record at Circuit Court of Appeals at San Francisco, Cal., within 30 days; and as the record cannot possibly be ready to forward in that time, and as a stipulation has been filed that statement of testimony on appeal may be settled within certain time, I do not now remember when; and as the record cannot be sent or prepared until after settlement of the statement on appeal, I would suggest that you at once pre-
1266 pare an order asking Judge Gilbert, U. S. Circuit Judge, to extend the time for filing record on appeal at least 60 days, Mineral Separation Co. vs. J. M. Hyde.

Please advise me at Missoula of receipt of this letter.

Yours truly,

GEO. W. SPROULE, *Clerk.*

[Endorsed:] No. ——. In the United States Circuit Court of Appeals, Ninth Circuit. Minerals Separation, Limited, and Minerals Separation American Syndicate, Limited, Complainants, vs. James M. Hyde, Defendant. Petition for Order Extending Time for Filing Record.

Copy.

United States District Court, District of Montana.

In Equity.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,
vs.
JAMES M. HYDE, Defendant.

It is hereby stipulated that the time for submission to the Court for approval of the condensed statement of the testimony in the above-entitled suit is extended to a date not later than November 3, 1913 and that counsel will submit simultaneously with said
1267 condensed statement of the testimony a condensation of the documentary exhibits.

Counsel for both parties request the Clerk to take no action upon that part of the defendant's precipe for transcript which refers to the documentary exhibits pending submission of the condensed statement thereof.

HENRY D. WILLIAMS,
Counsel for Complainants.
SHERIDAN, WILKINSON, SCOTT & RICHMOND,
Counsel for Defendant.

In the United States Circuit Court of Appeals, Ninth Circuit.

No. —.

MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Complainants,
vs.
JAMES M. HYDE, Defendant.

Upon petition of counsel, and for good cause shown, and the Court being fully advised in the premises,

It is hereby ordered, that the time for filing the record on appeal in the above-styled cause is enlarged and is hereby extended to and including the 8th day of December, 1913.

WM. B. GILBERT, *Judge.*

Oct. 7, 1913.

1268 [Endorsed:] No. 2346. In the United States Circuit Court of Appeals, Ninth Circuit. Minerals Separation, Limited, and Minerals Separation American Syndicate, Limited, Complainants, vs. James M. Hyde, Defendant. Order Extending Time for Filing Record. Filed Oct. 7, 1913. F. D. Monckton, Clerk. Refiled Dec. 1, 1913. F. D. Monckton.

1269 & 1270 United States Circuit Court of Appeals for the Ninth Circuit.

No. 2346.

JAMES M. HYDE, Appellant,
vs.
MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Appellees.

Upon Appeal from the United States District Court for the District of Montana.

Proceedings Had in the United States Circuit Court of Appeals for the Ninth Circuit.

1271 At a stated term, to wit, the October Term, A. D. 1913, of the United States Circuit Court of Appeals for the Ninth Circuit held in the court-room thereof, in the City and County of San Francisco, in the State of California, on Thursday, the nineteenth day of February, in the year of our Lord one thousand nine hundred and fourteen.

Present: The Honorable William B. Gilbert, Circuit Judge, Presiding; Honorable Erskine M. Ross, Circuit Judge; Honorable Frank S. Dietrich, District Judge.

No. 2346.

JAMES M. HYDE, Appellant,
vs.
MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Appellees.

Order Allowing Correction of Record and Order on Argument of Cause and Continuing Cause for Further Argument.

On consideration of the oral motion of Mr. Henry D. Williams, counsel for the appellees, and pursuant to the stipulation of counsel this day filed therefor, it is ordered that certain errors and omissions in the original certified typewritten Transcript of Record, and in the court-room thereof, in the City and County of San Francorrected by the clerk pursuant to said stipulation.

1272 Thereupon, ordered appeal in the above-entitled cause argued by Mr. Walter A. Scott, counsel for the appellant, and continued to to-morrow for further argument.

At a stated term, to wit, the October Term, A. D. 1913, of the United States Circuit Court of Appeals for the Ninth Circuit, held in the court-room thereof, in the City and County of San Francisco, in the State of California, on Friday, the twentieth day of February, in the year of our Lord one thousand nine hundred and fourteen.

Present: The Honorable William B. Gilbert, Circuit Judge, Presiding: Honorable Erskine M. Ross, Circuit Judge; Honorable Frank S. Dietrich, District Judge.

No. 2346.

JAMES M. HYDE, Appellant,
vs.
MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Appellees.

Order of Submission.

Ordered, appeal in the above-entitled cause further argued by Messrs. Henry D. Williams and John H. Miller, counsel for the appellees, and by Mr. Thomas Francis Sheridan, counsel for the appellant, and submitted to the Court for consideration and de-
1273 cision, with leave to Mr. Miller and to other counsel to file arguments.

At a stated term, to wit, the October Term, A. D. 1913, of the United States Circuit Court of Appeals for the Ninth Circuit, held in the court-room thereof, in the City and County of San Francisco, in the State of California, on Monday, the fourth day of May, in the year of our Lord one thousand nine hundred and fourteen.

Present: The Honorable William B. Gilbert, Circuit Judge, Presiding; Honorable Erskine M. Ross, Circuit Judge; Honorable William W. Morrow, Circuit Judge.

In the Matter of the Filing of Certain Opinions and of the Filing and Recording of Certain Judgments and Decrees of this Court.

Order Directing Filing of Opinions, etc.

Ordered, that each of the opinions this day rendered by the Court in the following entitled causes be filed by the clerk, and that a judgment or decree in each cause be filed and recorded in the Minutes in accordance with the opinion filed therein: * * * No. 2346. James M. Hyde, Appellant, vs. Minerals Separation, Limited, et al., Appellees.

1274 [*Opinion U. S. Circuit Court of Appeals.*]

In the United States Circuit Court of Appeals for the Ninth Circuit.

No. 2346.

JAMES M. HYDE, Appellant,
vs.
MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Appellees.

Thomas F. Sheridan, Walter A. Scott, and J. Bruce Kremer, for the Appellant.
Henry D. Williams, John H. Miller and Odell W. McConnell, for the Appellees.

Before Gilbert and Ross, Circuit Judges, and Dietrich, District Judge.

GILBERT, *Circuit Judge:*

This is an appeal from the decree of the Court below sustaining Letters Patent No. 835,120, issued to Sulman, Picard and Ballot, on November 6, 1906, and assigned to Minerals Separation, Limited, and Minerals Separation American Syndicate, Limited, adjudging the appellant herein to have infringed the same, and enjoying further infringement. The patent is for new and useful improvements in ore concentration. Its object is to separate metalliferous matter from gangue, by means of oils and fatty acids which
1275 have a preferential affinity for metalliferous matter. In the specifications reference is made to United States Letters Patent No. 777,273, granted to A. E. Cattermole. The Cattermole patent specifies that an amount of oil varying from four per cent to six per cent of the weight of metalliferous matter present is agitated with an ore pulp, so as to form granules which can be separated from the gangue. The specifications of the patent in suit state that the inventors have found that "if the proportion of oily substance be considerably reduced—say to a fraction of one per cent on the ore—granulation ceases to take place, and after vigorous agitation there is a tendency for a part of the oil-coated metalliferous matter to rise to the surface of the pulp in the form of a froth or scum," and the specifications add: "The proportion of mineral which floats in the form of froth varies considerably with different ores, and with different oily substances, and before utilizing the facts above mentioned in the concentration of any particular ore, a simple preliminary test is necessary to determine which oily substance yields the proportion of froth or scum desired." There are thirteen claims in the patent. The first is "the herein described process of concentrating ores, which consists in mixing the powdered ore with water, adding a small proportion of an oily liquid having a preferential affinity for metalliferous matter (amounting to a fraction

of one per cent on the ore), agitating the mixture until the oil-coated mineral matter forms into a froth, and separating the froth from the remainder by flotation." The next three claims specify the quantity of oil as amounting to "a fraction of one per
1276 cent on the ore." The second claim adds to the first the use of slightly acidified water. The third adds to the second, "warming the mixture." The fourth adds to the third "and removing the oily coating from the mineral." The fifth specifies the oil as "oleic acid of a quantity of from 0.02-0.5 per cent on the ore." The sixth adds to the fifth the use of water containing one per cent of sulfuric acid. The seventh adds "warming the mixture to 30°-40° centigrade." The eighth specifies the use of oleic-soap solution, to produce oleic acid, "amounting to 0.02-0.5 per cent." The ninth is "the process of concentrated powdered ores which consists in separating the mineral from the gangue by coating the mineral with oil in water containing a small quantity of oil, agitating the mixture to form a froth, and separating the froth." The tenth adds to the ninth "warming the mixture," and the eleventh adds the use of acid. The twelfth adds "separating the froth from the remainder of the mixture," and the thirteenth adds a current of water to carry off the coarser minerals, and "filtering off the froth and removing the oleic acid therefrom by treatment with an alkali."

The answer of the appellant denied that Sulman, Picard and Ballot were the first inventors of the process, or that there was any invention described in the patent, and denied infringement, and alleged that the process described in the patent was old and not patentable; that the process had been included in certain patents which were enumerated in the answer. The appellant was adjudged to have infringed claims numbered 1, 2, 3, 5, 6, 7, 9, 10, 11 and 12.

1277 The appellees' process depends primarily upon the affinity of oil for the metalliferous portion of powdered ore when mixed with water. It is conceded that that affinity and the fact that oil will carry the metalliferous portions to the surface of the mixture, while the rock or gangue will sink, have been known for many years. That which is presented as new in the patent, and as the pivotal discovery on which its validity depends, is the formation of a froth or scum containing the metalliferous matter produced by agitation of the pulverized ore in water, by the action of oil in a quantity less than one per cent of the quantity of ore treated.

Turning to the patents which are adverted to as showing the prior art, we find the following: The British patent to Haynes, No. 488, issued in 1860, recommends the use of from 11 to 25 per cent of oil by weight to the finely powdered ore, the mixture to be agitated with water, either warm or cold, until the earthy matter sinks and the metal is gathered by the oil. In that process the sunken earthy matter is removed, fresh ore is replaced, and the operation repeated with the same oil until it will take up no more metalliferous matter. The United States patent, No. 348,157, issued to Everson, in 1886, specifies the use of oil in quantities varying from five to eighteen per cent. Miss Everson was the first to make the im-

portant discovery that the affinity of the oil for the metal was increased by the addition of an acid. In the description of her process, she states that in the operation, the mass is broken up and thoroughly stirred in water, in a vessel provided with a mechanical stirrer, and having an outlet or outlets at the bottom for the
1278 escape of the water and sand. The Schwartz United States Patent No. 807,503, applied for in May, 1904, and granted in December, 1905, describes a process in which the dry ore is first mixed with enough oil to make a thick pasty mass, and water is thereafter added, and the mass is agitated so as to cause the metallic particles to float. The quantity of oil to be used is not further specified, but it is in the testimony that the Schwartz process has been experimentally used with cotton seed oil, the quantity used being 3.6 per cent of the ore treated. The United States patent to Kirby, No. 809,959, was applied for December 14, 1903, and granted January 16, 1906. The oil used by Kirby was kerosene oil in which five per cent of bitumen was dissolved. One of the claims is as follows: "The process of separating minerals, which consists in mixing together the pulverized mineral material, a considerable quantity of water and a solution of bitumen in a distillable hydrocarbon liquid, the proportion of bitumen in solution being substantially sufficient to insure the coating and entrainment of the mineral particles; and allowing the same to settle, and removing therefrom the floating layer of said solution and the mineral particles which have been coated thereby." In his specifications he says: "These materials to be so thoroughly agitated together as to finely subdivide said solution into small globules, and bring said globules into contact with substantially all of the pulverized mineral particles, which will by preference adhere to them." And in describing the means for the agitation, he specified a "vertically rotating shaft" in the mixing tank, which it is said is to be
1279 "rotated rapidly." No specific quantity of oil is prescribed, but it is stated in the specifications that a sufficient amount of the kerosene and bitumen in solution is to be used, "excellent results being obtained by using one-fourth to three-fourths as much by weight as ore." In the Froment Italian patent, issued May 20, 1902, and the British patent to Froment, issued June 4, 1903, the invention described is declared to consist "of a modification of what is known as the oil process of ore concentration." The modification consisted in releasing gas from the finely powdered ore, and "adding a suitable oil," resulting in a flotation of the oil and metal to the surface. Froment mentions the use of gas to aid in the flotation of sulfides reduced to powder and moistened by a fatty substance, in explanation of which the patentee says that if, for example, in a test tube there is placed ten grams of sulfurated copper ore, with its gangue, a gram of limestone, the whole reduced to powder, and there is added thereto 30 grams of water, a few drops of sulfuric acid "and a thin layer of ordinary oil," and the mixture is agitated for a second, the whole of the copper pyrite will instantly rise to the top of the liquid. The patentees of the appellees' patent purchased from Froment on November 17, 1903, the Froment patent, and Froment

agreed to send all possible information, together with the plans, drawings and a model plant, to England, for the use of the purchasers. The agreement was carried out in December, 1903. The instructions which Froment sent contain the following: "If the ore contains more than five per cent of metallic matter, such as
1280 copper, lead, it will be necessary to use a little more oil. As a general rule, one may assume 1% of oil for ore containing up to 5% of metals, 1½% of oil for ore containing up to 10%, and so on, up to ores containing 50% of metallic lead, which it was said would require 3½% of oil. In the instructions the mixing device is described as composed of a cylindrical body made of strong sheet iron, riveted with bolts, "in which two stirring devices work in opposite directions, making about 300 revolutions per minute." The Cattermole process, which is referred to in the letters patent in controversy in this suit, is presented in two British patents, one No. 777,273 and one No. 777,274, both of date December 13, 1904. The amount of oil specified in the Cattermole process is from four to six per cent of the weight of metalliferous mineral matter present in the ore. This quantity with the average ores would be less than one per cent of the mass treated. The fact that the final purpose of the Cattermole process is to increase the sinking tendency of the metalliferous mineral instead of removing it upon the surface, does not render that process any less instructive as to the state of the prior art, for there are two distinct steps in the treatment of the ore—there is first a violent agitation to cause the oil to gather up the metalliferous particles, as in the case of other oil flotation processes. Then follows a slow, smooth stirring of the mass, which releases the air from the froth or scum and causes the oil and metalliferous particles to adhere together and form granules of sufficient size and weight to sink, after which the mass at the bottom is drawn off, and the particles of sand and gangue therein are forced up-
1281 ward and thus separated from the granules of metal. Here is described a process in which a quantity of oil used approximates the quantity which is called for by the appellees' patent, a fraction of one per cent.

When the claims and the description of the process of the appellees' patent are compared with the patents of the prior art, it will be seen that the only material difference is in the smaller quantity of oil which the appellees use. Comparing the appellees' process with the Froment process, it will be seen that in both powdered ore is mixed with a sufficient water to form a freely flowing pulp; that while Froment recommends the use of oil of from one per cent to 3½ per cent of the ore by weight, the appellees recommend a fraction of one per cent of oil; that Froment recommends the use of ordinary oil or a suitable oil, while the appellees' patent mentions oils, fatty acids and oleic acid; that in both processes there is agitation of the mixture; that in both processes a small quantity of sulfuric acid is recommended; that in both processes the mixture of all the substances is made before the agitation; and that in both processes bubbles of air or gas are caught in the sulfides in the form of a froth which rises to the surface. So also in the Kirby patent, the

various steps of the process are similarly described. We find there the pulverization of the ore, mixing it with water to form a floating pulp, mixing therewith kerosene oil with a small percentage of bitumen, violently agitating the mass so as to bring the oil into contact with the mineral particles of the ore, causing the oil-coated mineral particles to rise and float on the surface of the
1282 water, while the gangue sinks to the bottom, and lastly skimming the floating concentrate from the surface of the liquid. But the appellees say that the Froment patent is a paper patent, and that therefore it is to be disregarded. A paper patent, if it fully describes an invention, whether it be a machine, device or process, is just as effective to show anticipation as a patent which describes an invention which has gone into extensive use, for a presumption of operativeness and of some utility attends the granting of letters patent. Packard vs. Lacing Stud Co., 70 Fed. 66; E. L. Watrous Mfg. Co. vs. American Hardware Mfg. Co., 161 Fed. 362; National Chemical & Fertilizer Co. vs. Swift & Co., 104 Fed. 87, 91; Universal Winding Co. vs. Willimantic Linen Co., 82 Fed. 228; Van Epps vs. United Box Board & Paper Co., 143 Fed. 869; Ironclad Mfg. Co. vs. Dairyman's Mfg. Co., 143 Fed. 512, 515; Dashiell vs. Grosvenor, 162 U. S. 425, 432. In Telephone Cases, 126 U. S. 1, 536, it was said: "The law does not require that a discoverer or inventor, in order to get a patent for a process, must have succeeded in bringing his art to the highest degree of perfection. It is enough if he describes his method with sufficient clearness and precision to enable those skilled in the matter to understand what the process is, and if he points out some practicable way of putting it into operation."

The fact that the appellees use a smaller quantity of oil than was used in the prior art is not of itself, and it is not claimed by them to be, sufficient to distinguish their process so as to render it patentable. To discover that the desired result may be accom-
1283 plished with the use of a fraction of one per cent of oil when formerly a much larger quantity of oil had been used, and had been deemed necessary, is not an invention or discovery within the meaning of the patent laws. It is a difference of degree and not of kind. "A change only in form, proportions, or degree, doing substantially the same thing in the same way by substantially the same means with better results is not such invention as will sustain a patent." Roberts vs. Ryer, 91 U. S. 150.

In Fried, Krupp Aktien-Gesellschaft vs. Midvale Steel Co., 191 Fed. 588, the Court said: "But mere useful and economical administrative methods, however valuable, while they may, and usually are incident to invention, do not themselves constitute invention." And in De Lamar vs. De Lamar Min. Co., Ltd., 117 Fed. 240-248, this Court, referring to the use of zinc dust for the purpose of precipitating mineral in a solution, said: "The right to use the dust being free to all, we think it follows necessarily that all have a right to adjust the quantity of the material to the necessities of each case, and ascertain by experiment or analysis, if need be, the quantity that may be required to produce the desired end; that such a use cannot be made the subject of monopoly, there being involved in it

no discovery, but only the exercise of ordinary prudence and skill." See, also, Brady Brass Co. vs. Ajax Metal Co., 160 Fed. 84; Commercial Mfg. Co. vs. Fairbank Co., 135 U. S. 176; Bullock Electric Mfg. Co. vs. General Electric Co., 149 Fed. 408; Lauman vs. Urschel White Lime Co., 136 Fed. 190; Tilghman vs. Proctor, 102 U. S. 707; Guidet vs. Brooklyn, 105 U. S. 550.

1284 But it is said that the appellees' process is the only froth process, and that the processes described in the prior art are the bulk flotation or oil buoyancy process. We have to inquire, therefore, what is the oil buoyancy process. It is described in the Elmore patents, No. 676,679, issued June 18, 1901, and No. 689,070, issued December 17, 1901, and in the testimony of Mr. Ballantyne, General Patent Counsel of the appellees. Mr. Ballantyne said that it was essential to this process, first, that the oil should be thick and viscous, for otherwise the metal would easily fall out of the oil; second, that the process be carried out in the cold, because if the oil be heated, it becomes thin, and will not entrap or float the mineral; third, that the mingling of the pulp and the oil be as gentle as possible, so to avoid breaking the oil into globules. And the appellees' expert, Dr. Chandler, testified that in the oil bulk flotation, 15.7 parts of oil must be used to 6.7 parts of ore. With these definitions and explanations of the oil buoyancy process in view, it is very plainly to be seen that in none of the patents herein discussed, aside from the Elmores', is that process used. The Haynes' patent uses 11 per cent of oil to the ore, and directs that the mixture be agitated with hot, warm or cold water, Kirby recommends thorough agitation by rapid rotation of the agitator, and he refers to the floating concentrate as a "scum." The Everson patent declares that thorough agitation of the mass or pulp, comprising water, the finely divided ore, the oil of fat and the acid, is necessary, and in the Engineering and Mining Journal of November 15, 1890, there is an article describing a test operation of that process, in which

1285 it was said that as the result thereof "a thick scum of sulfurets rose to the surface and was skimmed off, leaving the hitherto black ore as white as snow; in fact, pure silica." And so in the Cattermole process, although its ultimate purpose was to precipitate the metal in the form of granules to the bottom of the tank, it was first required that the mixture be thoroughly agitated, and as the result thereof, a froth necessarily came to the surface.

The contention is made, however, that if indeed the prior patents disclose froth processes, the scum which the appellees' process causes to rise to the surface of the water, is so different from the froth or scum which arises under the prior art, that it is a new result, and is not anticipated by anything in the prior art. Say counsel for the appellees: "You produce a froth which is not our froth," and again they say that the appellees' froth is "a pure metal froth," while that of the other patents is an "oil froth," and that the appellees' froth consists of air bubbles surrounded by metal armor without any appreciable quantity of oil connected therewith. The evidence in the case, together with the illustration thereof afforded by demonstrations of the various processes which were made in the aid of the

argument before this Court, convince us that the froth in all these processes is the same, with the exception that there is less oil (as there must necessarily be), in the appellees' froth than in the others. The froths are all similar in appearance, they all rise to the surface after the same amount of agitation, they all gather with
equal efficiency the same quantity of metal, and all may be
1286 removed from the surface in the same way. It is not literally
true, of course, that there is no oil in the froth which the appellees produce. If there were no oil in it, there would be no froth. The quantity of oil that has been put into the mixture must necessarily be found in the froth. It would manifestly be a physical impossibility to create a froth consisting only of bubbles of air and the particles of mineral. This is admitted in the specifications of the appellees' patent, in which it is said that there must be agitation "until the oleic acid has been brought into efficient contact with all the mineral particles in the pulp," and that the air bubbles which make the scum floatable adhere "only to the mineral particles which are coated with the oleic acid."

It is said in the appellees' brief that one feature of the froth produced by their process is that it is unnecessary to clean the mineral of the oil, as the infinitesimal oil coating has no adhesive effect, and that the concentrates may be freely tabled or vanned, and counsel say: "All you have to do is to gather that froth from these vessels, dry it out, and take it to the smelter." We find no evidence in the record that the froth which the appellees produce may be smelted without removing the oil therefrom, or that it would be a distinct advantage to do so, or that the froth produced by some of the anticipating processes may not be taken to the smelter without removing the oil. If the statement made in the brief is true, it is very clear that that feature of their froth was not known to the patentees at the time of their application for the patent, and is nowhere disclosed in the specifications or claims. The specifications deal only
with the production of the scum or froth, but Claim 13 in-
1287 cludes "filtering off the froth and removing the oleic acid
therefrom by treatment with an alkali," and on May 3, 1905, in a statement of their method of oil concentration which they sent to Australia, the patentees said, "The oleic acid is therefore of necessity recovered in the process and in the state in which it is required for re-use. This is not undertaken merely for the purpose of recovering the oleic acid, but as a necessary step in rendering the concentrates fit for vanning, separation into blende and galena."

The decision of the Court below appears to have been largely influenced by the consideration that the appellees' patent had gone into extensive and successful use. The fact that a patented device or process has gone into extensive and successful use is often of value in determining the question of invention and patentability. It is referred to for the purpose of turning the scales in cases of grave doubt. It is of no value whatever where the question of invention of patentability is free from doubt, and in any case its value depends largely upon the causes which produced it. It is often due to business ability in manufacturing, exploiting and advertising, and to

the fact that prior conditions have not stimulated development. The appellees' process, originally patented in Great Britain, has been installed in Australia, Sweden, Finland, Chile and Wales, and it is in the process of installation in Cuba. It is not improbable that in those countries the prior art may have been substantially unknown, and it is possible that the appellees' success there is referable to the fact alleged in the bill, "that the complainants have been to
1288 great trouble and expense in the introduction into use of the process, and have invested large sums of money in its introduction into commercial use in different parts of the world, and in the effort to introduce it into commercial use in the United States." It is in evidence that in making the process known to the public in the United States, the appellees have expended $60,187. Notwithstanding these efforts and expenditures, their process has not yet been installed in the United States. In Olin vs. Timken, 155 U. S. 141, 155, it was said: "While the patented article may have been popular and met with large sales, that fact is not important when the invention is without patentable novelty." In McClain vs. Ortmayer, 141 U. S. 419-428, the Court said that "the extent to which a patented device has gone into use is an unsafe criterion even of its actual utility, is evident from the fact that the general introduction of manufactured articles is as often effected by extensive and advantageous advertising, activity in putting the goods upon the market, and large commissions to dealers, as by the intrinsic merit of the articles themselves."

It would serve no useful purpose to review all the numerous decisions in patent cases that are cited by the appellees. But we will refer to two of them which seem to be especially relied upon—Naylor et al. vs. Alsop Process Co., 168 Fed. 911, and United States Mitis Co. vs. Midvale Steel Co., 135 Fed. 103. In the first of these cases, the Court held that an expert cannot take a process patent which has never been applied industrially and work the process in his laboratory, and discover therefrom something which is not disclosed
1289 on the face of the patent and then transfer that experience back to the time of the patent, and make it a part of the prior art for the purpose of defeating a subsequent patent for a meritorious invention. There is nothing in the present case to which that ruling applies, and it is to be observed that the Court sustained the patent in that case expressly upon the ground that the complainant therein was the first to discover a successful process for bleaching flour. The Court said: "His act was not selection of known agents in the art of bleaching flour, but was the discovery of the only agent that has yet been found to accomplish that result successfully in the milling industry." The second case is said by counsel for the appellees to be "conclusive." The invention there under consideration was a process for making steel castings homogeneous so as to prevent blow-holes, and it consisted in adding to the molten steel when it is about to be poured into the mold, a minute quantity of metallic aluminum. But the distinction between that case and the case at bar is plainly to be seen in the fact that there the inventor made a distinct addition to the known art. He added something which has

not been used by others, and which was effective in producing the result which was sought. In the present case nothing has been added.

We hold that to sustain the appellees' patent would be to give to the owners thereof a monopoly of that which others had discovered. What they claim to be the new and useful feature of their invention as stated by their counsel, is "agitating the mixture to cause the oily coated mineral to form a froth." As we have seen, that feature was
1290 clearly anticipated by the prior art, and when the elements of the appellees' claims are read one by one, it will be found that each step in their process is fully described in more than one of the patents of the prior art, with the single exception of the reduced quantity of oil which they use. The patentees of the appellees' patent made a valuable contribution to the art in discovering the smallest quantity of oil which would produce the desired result. In doing so, they pursued the course which all skillful metallurgists would be expected to pursue. They made a series of experiments to determine how small a quantity of oil could be used successfully. They found as all must find who apply the oil flotation process, that certain oils are adapted to use with certain ores, and that a larger quantity of oil is necessary for one kind of an ore than for another. The appellees admit that for some ores they use four times as much oil as for others. Their discovery that a small fraction of one per cent of oil is sufficient to produce flotation of the metalliferous matter cannot, as we have seen, be made by itself or in a combination the subject of a patent. The appellees cannot take from others the right to use oil economically. This was evidently the ruling of the Patent Office on their application for a patent. One of their claims in the original application was "the process of concentrating powdered ore, which consists in separating minerals from gangue by coating the minerals with oil in water containing a fraction of one per cent of oil on the ore, and recovering the oil coated minerals." This was rejected in view of the Cattermole patent "as expressing merely a difference of degree thereover as to the
1291 proportion of oily matter employed." Counsel for appellees admit that the claim was properly rejected for the reason that it leaves out the agitation and froth, and say "our invention is something else than the mere reduction of oil."

The decree is reversed, and the cause is remanded with instructions to dismiss the bill.

[Endorsed:] No. 2346. United States Circuit Court of Appeals for the Ninth Circuit. Opinion. Filed May 4, 1914. F. D. Monckton, Clerk U. S. Circuit Court of Appeals for the Ninth Circuit.

United States Circuit Court of Appeals for the Ninth Circuit.

No. 2346.

JAMES M. HYDE, Appellant,
vs.
MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Appellees.

Decree U. S. Circuit Court of Appeals.

Appeal from the District Court of the United States for the District of Montana.

This cause came on to be heard on the Transcript of the Record from the District Court of the United States for the District of Montana, and was duly submitted:

On consideration whereof, it is now here ordered, adjudged, and decreed by this Court, that the decree of the said District
1292 Court in this cause be, and hereby is, reversed, with costs in favor of the appellant and against the appellees, and that this cause be, and hereby is remanded to the said District Court with instructions to dismiss the bill.

It is further ordered, adjudged and decreed by this Court, that the appellant recover against the appellees for his costs herein expended, and have execution therefor.

[Endorsed:] No. 2346. United States Circuit Court of Appeals for the Ninth Circuit. James M. Hyde vs. Minerals Separation, Ltd., et al. Decree. Filed and entered May 4, 1914. F. D. Monckton, Clerk.

1293 & 1294 United States Circuit Court of Appeals for the Ninth Circuit.

No. 2346.

JAMES M. HYDE, Appellant,
vs.
MINERALS SEPARATION, LIMITED, et al., Appellees.

Petition of Appellees for Rehearing.

Henry D. Williams, John H. Miller, Wm. Houston Kenyon, Odell W. McConnell, Counsel for Petitioners.

Filed June 1, 1914. F. D. Monckton, Clerk.

1295 In the United States Circuit Court of Appeals for the Ninth Circuit.

In Equity. No. 2346.

JAMES M. HYDE, Appellant,
vs.
MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Appellees.

Petition of Appellees for Rehearing.

To the Honorable the Judges of the United States Circuit Court of Appeals for the Ninth Circuit:

The appellees hereby respectfully petition that a rehearing of the above entitled cause be granted by this Honorable Court for the following reasons:

The opinion of his Court appears to have been written in the belief that the prior art contains disclosures of mineral bearing froths produced by agitation for the concentration of ores. It is believed that upon rehearing it can be shown that the prior art does not contain any such disclosure. At the argument appellant's counsel made certain unproved alleged demonstrations of the prior
1296 art, and many statements not in any manner borne out by the evidence. Not only were the laboratory productions which were exhibited to the Court by the appellant at the hearing variant from and inconsistent with the described experiments of their expert witness which were alleged to represent the prior art, but they were wholly different from anything disclosed in the prior art. And the described experiments of appellant's expert witnesses were also wholly different from anything disclosed in the prior art.

Briefly summarizing:

1. Appellant's evidence does not describe a single experiment representative of the prior art.

2. Appellant's court demonstrations erred doubly in not representing the prior art and in not reproducing what had been testified to by appellant or his expert.

It is a fact established by the evidence that in March, 1905, the patentees of the patent in suit made the discovery of the fact, theretofore unknown, that by violent agitation of an ore pulp in the presence of a minute quantity of oil, a new phenomenon was produced, a persistent air froth carrying substantially all of the mineral content of the ore. The phenomenon was new in kind. The operation was new in kind. The new operation consisted in the separating out from the pulp under the conditions stated of substantially
1297 all the metal and concentrating and carrying that separated metal in a persistent and separable air froth. This Court appears to have been led to believe that the operation and the resultant phenomenon were old in kind and new only in degree. But that is an error of fact. They were both new in kind.
1297*a* The concentration of metals by oil was old, but the concentration of metals by a froth produced by agitation was wholly new. The object of the use of oil in minute quantities is to produce a froth. No such aim is suggested or mentioned in the prior art. Had such a conception existed, the prior patentees would not have directed the use of large quantities of oil. Oil is a mere incident to the production of the agitation froth and is used in such minute quantities that its sole function is froth-production and permanency. This has been decided by the Privy Council of the British Empire, the court of last resort there, since the argument of the case at bar, as appears at pages 43-5 of this petition post.

The appellant, equipped with the knowledge that had come from this truly wonderful discovery, applied that knowledge, used the efficient froth-beating apparatus that had been developed as a result of the patentees' discovery, accentuated the agitation to a still greater extent, and found that it was possible, using the proportions of oil of the prior art and the knowledge that had been given to the world by the patentees of the patent in suit, to produce an oily froth which would carry some of the mineral content to the surface. This was a further discovery, but it occurred after the invention in issue had been discovered and made known. Prior patentees never dreamt of doing what the appellant did in Court and what the appellant represented as the processes of the prior art. With the uselessness of these oily froths which the appellant exhibited to the Court we may not be concerned. The important fact is that they never existed in the prior art, that they are not described in the prior art, that they were not known in the prior art.

The very simplicity of the invention in issue has con-
1298 tributed largely to the plausibility of the misrepresentations of appellant's counsel at the argument. The process is a purely physical process. The mechanical operations are the agitation of an ore pulp with oil to produce a potential froth, substantial quiescence of the pulp to permit the froth to collect on its surface, and separation of the froth from the surface of the pulp. There is absolutely no chemistry in it. The operations are physical opera-

tions, the forces employed are physical and probably molecular forces, and the new phenomenon produced, the floating persistent air froth carrying substantially all the mineral content of the ore, is the result of purely physical forces. In prior processes employing oil, the oil, the ore and water were in some manner brought together with some agitation or mixing as is necessay in making any mixture of different substances, and, in a few instances, there was a floating mass of oil carrying some part of the mineral content of the ore. Yet the prior patents may be searched in vain for any disclosure of the production of a mineral froth by agitation. If the patentees of the patent in suit had not made their discovery, and the knowledge of the art was such as is contained in the prior patents, the world would never have known that it is possible to concentrate ores by the production of a mineral froth by agitation.

Another peculiarity in the history of the art, as shown by the documents written at the time and brought out by the appellant, is

1299 that the new result of the process of the patent in suit was produced under conditions such as had been assembled in the development of the Cattermole metal sinking process, and

that with certain of these conditions assembled, no other change was required to produce the new phenomenon of the agitation froth than the reduction of the quantity of oil. This is, in fact, set forth in the patent in suit. It not only clearly appears from the reports written at the time, but was illustrated in the demonstrations made in Court in behalf of the appellees, repeating experiments proved by witnesses.

Demonstration No. 1, repeating Dr. Liebmann's Experiment No. 3 (Rec., p. 624), employing oleic acid equal to 7% of the zinc sulphide, 2.125% on the ore, was performed in a Gabbett or cone mixer; agitation was carried on for ten minutes, then agitation was stopped, and with quiesence at the liquid there was practically no float at all. This was called to the attention of the Court at the time (Minutes of Arguments, p. 61). Had the operation stopped at this, it would have been an altogether useless operation. The metalliferous mineral and gangue had not been separated. The oiled metalliferous mineral was at the bottom of the Gabbett. This was a repetition of what had been done over and over again in the laboratory in the researches relative to the Cattermole process. It is proved overwhelmingly as a fact in the case that the Cattermole process did not produce a froth as a result of the agitation.

The agitation froth process was discovered in the identical apparatus which was used in Court for the above mentioned

1300 Cattermole operation, and the operation which brought about the discovery was repeated in this Court in appellees' demonstration No. 2. The agitation was the same as in the Cattermole demonstration and for the same period. Heat was employed at a temperature of 40° Centigrade or 104° Fahrenheit as at the time of the discovery. The proportion of oil was reduced from 2.125% on the ore to 0.1% on the ore. At the conclusion of the ten minutes' agitation, with quiescense of the liquid, a thick layer of the agitation froth rose to the surface carrying substantially all the

mineral content of the ore. This operation and this result were never attained in Cattermole, and were never even contemplated or dreamed of in the long research period of testing and improving the Cattermole process.

The misrepresentations of appellant's counsel as to the Cattermole process were made plausible by reason of the fact that in the laboratory tests of this process, which were no part of the general knowledge of the art, it had been found advantageous to employ a two-stage agitation, omitting the baffles of the Gabbett in the second agitation; but there is not a word of evidence to show that with this two-stage agitation a froth was produced at any stage of the operation. The evidence is wholly to the contrary. The Cattermole patent No. 777,273 does not describe this kind of two-stage agitation. It shows and describes agitation in four Gabbetts successively, separation of the light sands by upcast, and then agitation in two Gabbetts
1301 successively, and then final separation of the heavy sands from the granules by upcast. It mentions the use with certain ores in some stages of the process of a rolling form of agitation in cylinders or barrels to obtain good granulation of the mineral (Rec., p. 1193, ls. 46-50). This in the laboratory developed into the peculiar form of two-stage agitation above mentioned. This appears in the written reports made at the time (Rec., pp. 851-853), but nowhere does it appear that in this first stage of the Cattermole process as used in the laboratory, any mineral froth was produced. Cattermole agitation with Cattermole proportions of oil in the apparatus known at the time did not produce a mineral froth. The evidence on this point is overwhelming and uncontradicted. The Court has simply misapprehended the fact. The mineral froth did not appear in the history of the world until the invention of the patent in suit was made.

As to the proportions of oil to ore in the Cattermole process, the laboratory reports clearly show that the lowest proportion of oil to ore was 1½%, as appears in the reports of the tests which immediately preceded the discovery (Rec., pp. 889-891). The warning in the Cattermole patent against the use of lean ores, with the statement that with but little mineral present it would be necessary to increase the proportion of mineral, as by adding a portion already granulated "to maintain the necessary amount of mineral in
1302 the ore under treatment" (Rec. p. 1193), and the fact that the ores upon which the process was tried had a minimum mineral content of 30%, eliminates any force in the suggestion of appellant's counsel that Cattermole proportions could, in any event, have been the same as used by the agitation froth process. The mineral content or metalliferous mineral content is the proportion of metallic sulphide present, not the proportion of metal present, and roughly is half as much again as the metal content.

The fact is proved in the record by the appellant that the first commercial installation in this country of any process resembling that of the patent in suit was the installation by the appellant complained of as the infringement and made by the appellant after he had spent a year in the employ of the appellees. This first installa-

tion, therefore, resulted from the patented invention. The appellant, as the trusted employee of the appellees, had been sent to North America—United States, Mexico and Canada—to survey the field for the appellees. The appellees had theretofore been too busily engaged in their great work in Australia and elsewhere to introduce their process in the United States. They offered their process to the Butte & Superior Copper Company, Limited, and the appellant appeared in competition with them and was successful in obtaining permission to install the infringing plant.

Appellant's expert testifies:

"I do not know of any oil-gas flotation process for the sepa-
1303 ration of minerals ever having been commercially operated in this country other than the operations of Hyde" (Rec., p. 237).

Later he gives his classification of "oil-gas flotation processes" including the Everson, Schwarz, Kirby and Froment processes referred to in the opinion of this Court, and also endeavors to classify Cattermole as an oil-gas flotation process, reaching his opinion by mathematical computation, without test, in utter disregard of the proved facts of the case.

It is submitted that the attitude of the Court in the examination of these prior patents, from which nothing of value has come, is well expressed in the decision of this Court in San Francisco Cornice Co. v. Beyrle, 195 F. R., 516, wherein the first defense was "that the patent is void for the want of invention or discovery," and this Court said:

"With respect to the first defense, the rule is that the burden of proof is upon the defendant to establish this defense."

That rule was there applied in the examination of a number of prior patents and they were rejected as not disclosing the invention or discovery of the patent in suit. It is submitted that the burden is upon this appellant to show that, before the discovery of the agitation froth process in March, 1905, the thing then discovered was known. The proof offered by the appellant fails utterly in this respect. It is not proved that a mineral froth was produced by
1304 agitation in the concentration of ores or was known to be capable of production before March, 1905.

The appellant has failed to carry on any of the processes described in the prior art in the apparatus of the prior art, and has failed to point out in the prior art a description of the discovery. Appellant has merely used the most refined froth-beating apparatus which followed the discovery of the invention of the patent in suit and, by accentuation of the agitation, has done what no one did before, has produced oily floats resembling in appearance the agitation froth; but appellant has not proved what it was incumbent upon him to prove, to impart any evidential value to these demonstrations, to wit, that, with the apparatus and the knowledge of the prior art, such oily froths are capable of production.

The fact that the prior patents make no disclosures of the production of mineral froths by agitation was fully proved in the evidence.

The patents referred to in the opinion of this Court will now be considered.

Haynes British Patent No. 488 of 1860. This patent was set up in the Answer, but not introduced in evidence by the appellant. Appellees put it in evidence and briefly explained it because of its historical importance as the first published effort to utilize an oily material in the concentration of ores, and because it was the first failure of this art. It does not disclose a flotation process. It describes the mixing of the ore with a sticky agent so as to
1305 "incorporate the whole together" (Rec., p. 1006, l. 13), then the addition of water sufficient "to cover the whole bulk" (l. 14) and continuation of agitation in the mixing machine or treatment in a triturating machine, such, for example, as a mortar and pestle, whereby the earthy or foreign matter is separated from the agent and metal "which alone remain in union" (l. 20), then the removal of the earthy or foreign matter and its replacement by fresh ore until the agent "will take up no more metal" (ls. 21, 22). This produces a putty-like mass of the agent and metal. Further the mixing machine is specifically described as "an ordinary brick maker's pug mill or mortar mixer" (Rec., p. 1007, ls. 24, 25), although any other apparatus that will effect the due mechanical admixture of the agent and the ore is generally referred to, and here again it is clear that the mixture is made without the presence of water, and then water is added "sufficient to well cover the whole" and the agitation is kept up and gradually effects the separation of the metal "the earthy matter sinking to the bottom of the water and the metal being retained by the agent" (ls. 31, 32).

It is very evident here that the metal is retained in the putty-like mass of ore and agent. This is further made clear in the statement that the agent and metal "still in union" (ls. 35, 36) are put in a vessel containing an alkali, with the result that the oily material is changed to soap and dissolves in the water and is thus
1306 separated from the metal, which falls to the bottom of the alkaline solution. This process is best described by Mr. Ballantyne (Rec., p. 445). Briefly, it consists in forming a mortar-like mass of oil and ore and washing the gangue out of this mass in water. From the beginning to the end of the specification there is no mention of floating the metalliferous mineral. Appellant's brief is wholly misleading as to this fact (Appellant's Brief, pp. 79, 80).

Everson Patent No. 348,157 of 1886. This patent describes two methods of procedure. The first is Haynes' with the addition of a mineral acid, such as sulphuric acid. A mixture of oil, acid and water is produced in a complicated manner and this compound is added to the water so as to produce "a stiff mass after the materials have been incorporated" (Rec., p. 1099, ls. 36, 37). After this stiff mass has been produced, the gangue is washed out of it by the action of water "applied to the mass" (l. 46). For treating a small bulk "The mass may be squeezed repeatedly in the hand in a basin of water, the substance so manipulated being expressed between the fingers each time it is squeezed, and thus made to expose new surfaces

to the water from which the sand will be detached so as to fall to the bottom of the basin" (ls. 52-60).

1307 Then it is said that, in practice:

"Upon large masses any vessel having an outlet or outlets at its bottom for the escape of the water and sand will be suitable for this operation of washing, and mechanical means will, of course, be employed to break up the mass" (ls. 60-65).

The result of this operation is then described:

"The concentrated mineral will accumulate in a pasty mass or lump or lumps" (ls. 65-67).

Appellant's brief is misleading as to this point. It describes the washing operation in a vessel provided with a mechanical stirrer and having an outlet or outlets at the bottom for the escape of the water and sand, and says that the mineral will accumulate in a pasty mass, but suppresses the reference to the production in a "lump or lumps," which so clearly establishes the fact that the product was not a froth (Appellant's Brief, p. 83).

This first method of Everson is so remote from the process in suit that appellant's expert passed it by without explanation.

The second Everson method is not wholly of the paste or pudding type and it is this method which the appellant's expert laid stress upon and pretended to reproduce. It is not a flotation process. A thin oil, petroleum, is used and mixed with the dry ore, and the dry ore is then put in acidified water. Here we start with an oily mass, for it is said that the quantity of acid is "sufficient to cut the

1308 sand away from the otherwise cohering mass" (Rec., p. 1099, ls. 81-83). The mixture is then subjected to "thorough agitation of the mass and detachment of the sand" (ls. 99-101), and the sand is preferably removed "by means of a constant overflow of water from a washing-out vessel, by which overflow the concentrate will be floated off" (ls. 101-105).

The meaning of the word "floated" here used is then made clear, for the patentee says: "bearing in mind that the sand and mineral are merely transposed or their relative positions are reversed, because the sand is heavier than the mixture of mineral, oil and acid" (ls. 107-111).

This description is perfectly clear and the patentee's statement that the two substances are merely transposed, that is to say, the originally heavier mineral mixed with the oil is now lighter than the sand, so that it can be separated from the sand by the constant overflow of water from a washing-out vessel, describes the well known up-current classification. The mixture of mineral, oil and acid having now been made merely lighter than the sand is carried off by this up-flow or overflow just as in the Cattermole process the sand is carried off in the overflow or upflow. Everson lightened the mineral by using a considerable quantity of oil, but not sufficient oil to float it by buoyancy. Cattermole accentuated the resistance of the min-

1309 eral to a current of water by causing the particles of mineral to adhere together and form granules which, by reason of their increase in the proportion of weight to surface, resisted an up-

flow which carried away the particles offering least resistance to the upflow, to wit, the gangue or sand particles. Both processes are displacement processes in which particles are separated by currents of water. In neither process is there any flotation at the surface of a liquid. Neither process produces a floating froth.

Concrete examples of this are afforded by Dr. Liebmann's tests of the Everson process, wherein, as he testifies, "The specific weight of the mixture of oil and mineral of the first example was 1.8, the specific weight of the gangue 2.5; the specific weight of the mixture of oil and mineral of the second example was 1.7, of the gangue 2.5" (Rec., p. 722).

These examples exactly illustrate what Everson so clearly describes, the production of a condition wherein the sand and mineral are merely transposed because the sand is heavier than the mineral and oil, but both are heavier than water.

Appellant's expert testifies that he carried out the operation of the Everson patent by using the highly efficient froth-beating apparatus known as the Slide Machine, which was invented in 1909, four years after the agitation froth process was discovered. He used all the knowledge which the invention of the patent in suit had given
1310 to the world, and the highly efficient apparatus which had been developed for testing the invention of the patent in suit, and, by taking off nine floats sucessively, without addition of oil after the first operation, he produced what he said was a concentrate; but, as he gives no assay of it, the fact that he did produce any substantial concentration should be doubted. Whatever he did and whatever he produced, he did not use the apparatus known and used in the art at the time of the Everson patent, 1886. This application of later knowledge in an operation inconsistent with the Everson patent, was objected to, with others of like character, as "not carried out with the procedure or in apparatus such as are disclosed" in the prior patents referred to (Rec., p. 224). Certainly such a test cannot be accepted as evidence to destroy a valuable invention.

Appellant's Court demonstrations did not include anything resembling their expert's alleged carrying out of the Everson process.

Schwarz Patent No. 807,503, applied for May, 1904, granted December, 1905. This is the first one of the prior patents referred to in the opinion which describes flotation. The aim of this process is to produce a floating layer of oil carrying the mineral entrapped in the oil, and it is, therefore, a process of the oil buoyancy type. This is quite clear from the specification. Schwarz first mixes oil with the ore so as to form a thick pasty mass, then he puts this thick pasty mass into water and agitates "until the water is distrib-
1311 uted throughout the mass. The mass is then allowed to subside, when the selective material, with the entrapped metallic constituents of the ore, will rise to the top and may be removed in any suitable manner, as by floating over the top of the vessel" (Rec., p. 1215, ls. 63-69).

This entrapping of metallic constituents in the selective material, oil, is a characteristic feature of oil buoyancy processes. Schwarz

also contemplates increasing the buoyant power of this floating layer of oil by blowing in air, steam or gas. This he says will break up and subdivide the mass and "furthermore, it results in the selective material, taking up an appreciable quantity of air or gas, giving a certain amount of sponginess, which increases its floating power" (Rec., p. 1215, ls. 92-94).

The selective material, oil, is to take up an appreciable quantity of air or gas, thereby giving a certain amount of sponginess which increases the floating power of this oil. The theory of this operation is perfectly clear. Schwarz hopes to improve oil buoyancy by entangling, here and there in the layer of oil, bubbles of air or gas, which, like the interior cavities of a cork or sponge, will make the mass lighter. The suggestion that the air or gas gives a certain amount of sponginess to the oil layer makes this apparent. A suggestion of giving a certain amount of sponginess to a froth would be ridiculous, yet appellant's expert, in construing this patent,
1312 says that the agitation of this pasty mass in water will produce a floating froth of concentrates and that the injection of air, steam or gas will give the froth sponginess (Rec., p. 203). Giving a froth sponginess is like gilding pure gold.

The Court has been misled by the statement of appellant's brief that appellant's expert found that the amount of oil necessary to form a thick mass, suggested to be such as Schwarz described, was 3.6% of the ore (Appellant's Brief, p. 47). Appellant's expert did carry on an alleged Schwarz test with that proportion of cottonseed oil, but appellant's expert did not testify that this proportion of oil produced a thick pasty mass. He merely said that it gave "a homogeneous mass having the consistency of molding sand" (Rec., p. 210). Molding sand is sand which is scarcely perceptibly damp; therefore, it is not in evidence that a thick pasty mass of ore is capable of production by the use of 3.6% even of this selected oil, which was not specifically mentioned in the Schwarz patent, cottonseed oil. It is in evidence that to produce such a thick pasty mass according to Schwarz it is necessary to use 50% of oil. Dr. Liebmann so testifies (Rec., p. 671). Dr. Chandler attempted to carry out Schwarz with the fatty material described by Schwarz and used first 33⅓ per cent. of the mixture of paraffin wax and crude petroleum described by Schwarz, and then had to increase the amount to 50% to get anything approaching Schwarz's description (Rec., p. 747).
1313 The alleged carrying out of the process of the Schwarz patent testified to by appellant's expert was wholly inconsistent with that patent in every respect. Appellant's expert used the modern Slide apparatus, invented in 1909. He used cottonseed oil which Schwarz does not suggest. He omitted thick fatty matter, which Schwarz makes an essential part of his process. He used this thin oil, cottonseed oil, in the proportion of 3.6% instead of what he should have used, 50% (Rec., p. 210). He omitted altogether the injection of air or steam or gas (p. 211). He carried on, in fact, the procedure made known to the world in connection with the invention of the patent in suit, with a peculiar and especially selected

oil not described by Schwarz, and by six successive operations, without oil addition after the first operation, says he obtained a floating froth and says he obtained a fair amount of concentration. The testimony as to the experiment was objected to as not carried out with the procedure or in the apparatus of the Schwarz patent (Rec., p. 224).

Appellant's second Court demonstration (Slip No. 12, Minutes of Argument, p. 22), although not particularly identified at the argument, resembles this alleged Schwarz operation, except that the period of agitation was increased from thirty seconds, described by appellant's expert, to one minute and twenty-five seconds, and that the rectangular vessel was provided with baffles to greatly magnify and increase the amount of agitation. This use of baffles in
1314 a rectangular vessel was not disclosed in the testimony of appellant's expert, or in the testimony of the appellant himself, who testifies to a similar test. For that reason, attention was called to the fact by appellees' counsel at the argument. It shows that appellant's laboratory demonstrations, not representative in any manner of the prior art, require not only the high degree of agitation of the highly developed froth-beating apparatus the invention of which followed by some years the invention of the patent in suit, but, in addition thereto, an increased agitation. The fact that it was necessary to use these baffles in the Court demonstrations impeaches the truthfulness of the testimony of appellant and his expert.

The Court will observe that Schwarz claims the use of

"a mixture of a liquid hydrocarbon and a normally solid fatty matter, which mixture is solid at normal temperatures" (Claim 1, Rec., p. 1216, ls. 39-42);

and specifically

"a mixture of a liquid hydrocarbon and paraffin, which mixture is solid at normal temperatures" (Claim 6, ls. 83-85);

and that throughout his claims it is repeatedly said that the values or minerals are entrapped, and that in the specification he speaks of "the entrapped metallic constituents of the ore" (Rec., p. 1215, ls. 66, 67). There cannot be the slightest doubt that this is
1315 an oil buoyancy process of the Elmore type, but differing from Elmore, else it would not have been patented. Schwarz exactly describes the Elmore process as the prior art that he improves upon (Rec., p. 1215, ls. 12-27). His improvements are using a normally solid oily and fatty material, keeping it fluid by heat during his operation, and blowing into it air or gas to produce interior cavities in this floating mass and thereby increase its floating power. The specification may be searched in vain for any description of the production of a froth by agitation. Appellant has utterly failed to carry out the process of this patent and, with all the knowledge and refined apparatus which appellant uses, has utterly failed to produce a floating froth of concentrates even using the materials and proportions of the Schwarz disclosures.

Kirby Patent No. 809,959, applied for December 14, 1903, granted January 16, 1906.

The Kirby process is clearly a modification of the Elmore oil buoyancy flotation process, wherein a thin oil, kerosene, is used in place of the thick petroleum residuum of Elmore, and the adhesiveness of the thin oil is increased by dissolving bitumen in it which is said to give

"The precise adhesive preference which enables it to separate the gold and chalcopyrite from the crushed ore" (Rec., p. 1222, ls. 12-14).

A further modification of the Elmore process is that Kirby
1316 proposes to render the separation substantially complete

"by gently agitating the mass and by injecting gas into the same and preferably also by discharging into the mass fine streams of the solution" (Rec., p. 1221, ls. 81-85).

The function of the air or gas introduced by injection is clearly set forth. The patentee says:

"The injection of a gas, preferably air, into the mass, which is the chief novel characteristic of the second stage of the process, assists in the flotation of the hydrocarbon coated particles" (Rec., p. 1222, ls. 44-48).

Further the patentee says:

"Some of the hydrocarbon coated particles will float to the surface without assistance; but a considerable quantity of such particles will not be sufficiently buoyant, and some of such particles and some globules of the mixture would be trapped in the sands" (Rec., p. 1222, ls. 53-59).

This clearly shows that oil buoyancy is relied upon and will be sufficient to float some of the particles, but that, by reason of the fact that Kirby uses less oil than Elmore, some of the particles will not be sufficiently buoyant, and air bubbles will help them and will keep them floating by reason of the fact that the bubbles of air will become entangled in the floating mass of oil, and, as he says, some of the oil globules might be trapped in the sands,
1317 in which event their flotative power would not be effective, and so he must turn the mass very gently to release these oil globules and give them a chance to float.

The process, therefore, resembles that of Schwarz. Air bubbles are introduced into a floating mass of oil to produce interior cavities which will increase its flotative power. Although the patentee uses a thin oil, made adhesive by bitumen, he says, relative to his second step, injecting air and oil and gently agitating:

"The prior processes which use thick, viscous oils will, however, be much aided by the addition of this step, because in spite of all the care which is exercised in the practice of those processes to keep the oil in large clots or masses a great deal of it is 'floured' or broken up into minute particles which are entrapped in the sand and lost. The employment of the gas in the manner stated brings in a more powerful floating agency than anything before use-, which results in the recovery of this floured oil, together with numerous coated

particles which would not otherwise be floated. This step of the process is therefore useful with any and all liquids lighter than water which exhibit preference of adhesion for the metallic mineral particles" (Rec., p. 1221, l. 102; p. 1222, l. 6).

In other words, it is useful in all other oil buoyancy processes.

This process is wholly misrepresented in Appellant's Brief. Indeed, the misrepresentation is elaborate. The effort is made
1318 to separate the first step of Kirby's continuous process into a separate process. By a mutilated quotation (Appellant's Brief, p. 147) it is represented that Kirby proposed simply to agitate in one vessel and permit the hydrocarbon coated particles to float to the surface of that vessel. Nothing of the sort appears in the Kirby patent. Kirby has first a cylindrical agitation vessel A, which he calls "the mixing tank" (Rec., p. 1222, l. 102). It has a smooth circular contour and is unprovided with baffles or any liquid restraining means, and in it such violent agitation as would be necessary to produce a froth could not have been produced or contemplated, as is indeed indicated by the illustration of that vessel. Agitation for the production of the agitation froth involves the breaking of the surface of the liquid and the drawing down into the whirling mass of the liquid of great quantities of air. Kirby indicates by a dotted line the small surface waves produced by his agitation. Kirby's agitator is a complicated affair with plow attachments, totally unfitted for high speed. His "rapid" rotation was such as was known at the time of his invention. He did not dream of beating a pulp into a froth.

Kirby's process is continuous, and the ore pulp, oil and water that are mixed in his first vessel A flow into his second vessel B, and in the second vessel there is a gentle agitation accompanied by the injection of streams of air and streams of oil. The
1319 curved skimming bar which revolves on the upper surface of this liquid is fastened to the same shaft as the gentle stirrers which revolve at the bottom of this liquid. Kirby "thoroughly" agitates in the first vessel so as to break up his oil into small globules, which globules of oil will come in contact with substantially all of the mineral particles, and in his second vessel he gently agitates the mass and injects the gas and streams of the oil and skims the floating layer of oil and mineral and some air bubbles from the surface. That Kirby produced such a floating layer of oil and did not produce a froth is plainly apparent in Kirby's specification. He says:

"The floating concentrates are carried mainly at the lower surface of the hydrocarbon layer, where it is in contact with the water" (Rec., p. 1223, ls. 55-58).

This is a characteristic of every oil buoyancy float and is not at all a characteristic of a froth wherein the individual bubbles are loaded with the mineral.

Kirby's next apparatus after his tank B for gentle agitation and skimming is an oil separator C. Here again we find that he is dealing with a buoyancy float, for he says:

"Most of the concentrates hang near the contact between the hy-

drocarbon and water, and as this contact surface becomes overloaded with concentrates, some of them sink to the bottom of the tank" (Rec., p. 1224, ls. 20-25).

In this vessel he effects a separation of some of his oil
1320 layer from some of his concentrates, for he says:

"The excess of hydrocarbon, accompanied by some of the concentrates, falls out through the launder 43" (Rec., p. 1224, ls. 25-27).

The thicker material falls downward and thus he separates into two streams, one being a stream of oil containing a small portion of the mineral and the other a stream mainly of water and the mineral, for he says:

"The two streams, one of hydrocarbon and concentrates, the other mainly of water and concentrates, may either be filtered in separate apparatus or united and put through the same apparatus, as is found most convenient" (Rec., p. 1224, ls. 37-41).

And then follows a description of the elaborate filtration apparatus, including the centrifugal machine or filter presses of the Elmore process, and a distilling apparatus, all of which clearly point to the fact that Kirby was dealing with a process in which he produced a floating layer of oil wherein the mineral was entrapped, and that the only function of the air injected into the liquid was to produce air bubbles in this floating liquid mass of oil which flowed in streams through the apparatus. The stream of "hydrocarbon and concentrates," that is to say, oil and concentrates, could not possibly be a froth of bubbles armored with concentrates. Nor could the stream of "water and concentrates" be a froth.
1321 Kirby's specification not only fails to describe or suggest a froth, but excludes it.

This is equally true of Kirby's description of his float on the surface of the gently rotating liquid in Kirby's second vessel B. He describes this float as a

"floating scum of hydrocarbon liquid, air bubbles, and concentrates" (Rec., p. 1223, ls. 38, 39).

The word scum, while it is a generic term broad enough to include the specific character of float properly described as a "froth," described any float of extraneous matter which rises to and floats on the surface of a liquid. It is defined in the Standard Dictionary as:

"Impure or extraneous matter that rises to or collects upon the surface of liquids."

A froth is defined in the Standard Dictionary as

"A mass of bubbles resulting from fermentation, effervescence or agitation."

A froth is of necessity a mass of bubbles, but a scum may not have any bubbles at all. It is true that in the specification of the patent in suit the word "scum" is loosely used, associated with the word "froth," but the claims of the patent in suit, performing their function of defining the invention, accurately use the word "froth" only, and define the froth as a froth produced by agitation.
1322 Thus we find that Kirby expects to so thickly coat and entrap some of his mineral particles that they "will float to

the surface without assistance," this being oil buoyancy, unassisted, but hopes to assist flotation by air injection, not by beating in air—by an air injection after thorough mixing of oil and ore—with gentle agitation and the injection of streams of oil, by providing, in connection with this gentle agitation, the action of a skimming bar on the surface of the gently rotating liquid which will sweep the particles off as fast as they come to the surface. This is his process of separating mineral from gangue, well described in the specification, and certainly the appellant did not repeat that process in Court or anything like it. Nor was that process repeated in the single alleged Kirby demonstration which appellant's expert says he made. The Court has not seen that process at work. The only intelligent explanation of it, aside from the patent itself, is to be found in the testimony of appellees' experts (Rec., pp. 567-573; p. 677; pp. 773-775).

While it is true that Kirby allowed some latitude as to the quantity of oil used, he certainly required sufficient oil for a substantial amount of oil buoyancy. He says he uses

"a sufficient amount of the kerosene-bitumen solution, excellent results being obtained by using one-fourth to three-fourths as much, by weight, as ore" (Rec., p. 1222, ls. 27-30).

1323 That is to say, he obtains excellent results with from 500 to 1500 pounds of oil to the ton of ore, but, in any event, he uses sufficient oil for carrying out his process. It is in evidence that in the test of appellant's expert alleged to be, but in fact not at all, a carrying out of this process, wherein the ore contained 30 per cent. of blende or zinc sulphide, the 25 per cent. of kerosene used, bitumen being omitted, would theoretically float by buoyancy 43.2 grams of the 150 grams of the zinc sulphide present, and that if appellant's expert had used 75 per cent. of kerosene, it would theoretically have floated by buoyancy 129.6 grams of the sulphide, or about 86.4% of the sulphide (Rec., Chandler, pp. 782, 783). With a leaner ore, Kirby's directions provide for sufficient buoyancy to float the whole mineral content without assistance from air bubbles.

Appellant's expert pretended to carry out Kirby (Rec., p. 209). He did not use Kirby's complicated apparatus or anything like it, he did not use Kirby's specified ore, he did not follow Kirby's directions. He did use the highly-developed froth beating apparatus of the agitation froth process, the slide machine. He used Kirby's minimum quantity of kerosene, and he says he succeeded in producing a floating froth of concentrates, but he gives no assays, and the efficiency of the operation may well be doubted. After he had produced what he says was a froth by beating air into the pulp, he says he

1324 roughly imitated Kirby's air injection by the use of an air tube pushed down into the tailings. He does not say that this helped at all, and yet this was Kirby's only method of introducing air. What he did is of no evidential value as representative of what Kirby disclosed. It was objected to as not carried out with the procedure or in apparatus such as disclosed in the Kirby patent (Rec., p. 224).

Appellant's first demonstration in Court (Slip No. 8, Minutes of

Argument, p. 9), was intended to reproduce this experiment of his expert. The use of baffles in the square vessel was a substantial departure from the description given by the witness. Kirby had a round vessel without any baffles to restrain the rotation of the liquid. Appellant used in Court a square vessel, in itself sufficient to restrain rotation for the agitation froth process, and the highly efficient froth beater of that process, and was compelled in addition to use a baffle to magnify the agitation. It is believed that this demonstration, and others of like deceptive character, have misled the Court. A valuable patent should not be destroyed by any such representations.

As an example of the reckless statements of appellant's counsel may be noted the statement that with 75 per cent. of oil he would get the same flotation (Minutes of Argument, p. 23). For this th-re is absolutely no foundation in testimony or demonstra-
1325 tions, and this was used as the especial basis of the argument that the process of the patent in suit introduced no change in kind, but only in degree.

Froment Italian and British Patents of 1902.

This process is different from all those referred to above and from the agitation froth process of the patent in suit, by reason of the fact that it is one wherein chemical action is relied upon. A chemical reaction, almost explosive in nature, in the presence of a large quantity of oil, produces a thick floating magma or pasty mass, with bubbles of carbon dioxide in it, which carries a fair proportion of the mineral. Agitation for one second, five shakes, produces this magma. Agitation for another second diminishes it by half, and sends most of the metal to the bottom. Agitation for successive seconds practically destroys it. This was proved in evidence (Rec., Chandler, pp. 760, 761) and demonstrated in Court (Appellees' Demonstration No. 5). Chemical action produced this float. A comparatively slight agitation destroyed it. The patents disclose only a useless test tube experiment. It is respectfully submitted that there is no presumption of operativeness and utility from such a patent. The American Patent Office would not have granted it.

Froment Descriptions, Drawings, and Apparatus.

Here we have a description of a metallurgical process and its apparatus. It involves,

1326 (1) Careful grinding of the ore to avoid too much slime or "impalpable particles" (Rec., p. 828).

(2) "Eliminating the slime which is too fine to be treated and which could not be treated by any hitherto known method" (Rec., p. 828).

(3) Agitation of the deslimed ore for ten minutes in a centrifugal mixing apparatus, with oil and limestone (Rec., p. 829).

(4) Discharging the mixed material into a vat in which there is a gentle mixing apparatus making 10 to 12 revolutions per minute, "so as to prevent the ore from collecting at the bottom in too compact a mass" (Rec., p. 830).

(5) Introducing sulphuric acid at the bottom of this vat from a coil. "As soon as the acid has reached the vessel and begins to mix with the ore, the reaction will at once begin, and the greatest part of the greased sulphides will rise to the surface, carried by the gas bubbles" (Rec., p. 831).

This process is materially different from the test tube experiment described in the Froment patents, although it embodies the same basic idea, flotation of oiled mineral by the chemical generation of the gas, carbon dioxide, in an ore pulp.

The apparatus went to the junk heap long ago (Rec., pp. 313, 338, 354). Reproductions of the mixer and vat with coil are in
1327 evidence (Rec., pp. 506, 788). They were tested by Dr. Liebmann and Dr. Chandler in careful accordance with the Froment description (Rec., pp. 651, 652; p. 767). After agitation for ten minutes in the mixer, the agitation was stopped and the oiled ore all settled to the bottom of the mixer (Rec., p. 651). Then agitation was started and the oiled mineral run into the vat with coil, and here sulphuric acid was added, the chemical reaction took place, bubbles of carbon dioxide came to the surface, but practically no mineral was brought up by them (Rec., p. 652). Then the best mixer known at the time, the Gabbett or cone mixer, was used, the operation of mixing repeated, and after ten minutes' agitation, the agitation was stopped, and no mineral came to the surface (Rec., p. 653). This was repeated in Court (Appellees' Demonstration No. 7), and your Honors will remember that, after this ten minutes of agitation, absolutely nothing came to the surface when the mixture became quiescent. There was no float at all. This demonstration was in exact accordance with the sworn testimony of eminent scientists, repeating an experiment which appellees' counsel had offered in the testimony to repeat in the presence of appellant and his counsel (Rec., p. 691). This offer was made as to every prior art experiment testified of by Dr. Chandler and Dr. Liebmann (Rec., pp. 691, 784). No such offer was made in behalf of appellant, and
1328 while the objection as to competency was overruled in the Court below, the fact goes to the credibility of the testimony of appellant's expert.

It has thus been indisputably proved as a fact in the case that agitation according to the Froment description in the best agitating apparatus known in 1902, does not produce any float at all. The proportion of oil was 2½% on the ore (Rec., p. 655).

Opposed to this proved demonstration we have the fourth demonstration of appellant (Slip numbered 10, Minutes of Argument, p. 36). This was not a repetition of anything proved by a witness. It was a presentation by counsel of his own interpretation of the Froment directions. The important step of desliming was omitted. Two per cent. of the same oil, mineral engine oil, as in appellees' proved demonstration, was used. With three and one-half minutes' agitation in a highly efficient froth-beating apparatus with additional baffles, such as used in all of appellant's demonstrations, an oily frothy float was produced. Acid was then added, with no ap-

parent result. The demonstration proved nothing. It should not have the slightest influence with the Court.

Fundamental differences between anything that Froment disclosed and the process of the patent in suit are that Froment uses acid in comparatively large quantities solely for its chemical action,

1329 while the process of the patent in suit, if it uses acid at all, uses it solely for its physical action and to that end always in small quantities (Spec., Pat. in Suit, p. 1, ls. 44-51), and may in some instances dispense with it altogether (Claims 1, 5, 9, 10, 12); that Froment's float is chemically produced and is destroyed by reasonable agitation, while the agitation froth of the patent in suit is produced by agitation.

Engineering & Mining Journal, Criley-Everson Process

This article (Rec., p. 837) fails to give any such instructions as will enable the operation referred to to be repeated. It says that the oil used is a "black thick oil," but does not specify any quantity. It says that water was heated to near boiling and to it was added sulphuric acid "enough to give it a tartish taste." It says,

"This acidulated water was then mixed with a mass of oil and ore, a thick scum of sulphurets rose to the surface and was skimmed off, leaving the hitherto black ore as white as snow—in fact, pure silica."

The most that can be said of this description is that it is to some extent consistent with the disclosures of the Elmore oil buoyancy patent. The results stated may or may not have been produced. No one has attempted to repeat this operation in evidence. At best, it is a newspaper article which fails utterly as a definite disclosure of any process whatsoever.

1330 The statement that the aciduated water was "mixed" with the mass of oil and ore excludes any possibility that there was any such violent agitation as would have been necessary for the production of a froth by agitation.

The Court will remember that the Elmore buoyancy float which was produced in Court (Appellees' Demonstration No. 4) was a thick oily mass, to which the name of "a thick scum" might well be applied by a newspaper reporter.

In confirmation of the fact that great quantities of oil were used in this Criley-Everson experiment for oil buoyancy flotation, we find that the next published disclosures by Carrie Everson are two patents, one to her and Hebron, No. 471,174 of 1892 (Rec., pp. 1120-1128) and the other to Hebron as sole inventor, but partly assigned to her, Hebron patent No. 474,829 of 1892 (Rec., pp. 964-972) wherein the use of oil was abandoned, evidently because of the cost of the great quantities necessary, and a buoyancy effect was attempted with other material, such as sawdust, as a substitute for oil.

Patent in Suit.—The proportion of oil especially recommended in the patent in suit is one-tenth of one per cent., one one-thousandth of the weight of the ore. Buoyancy by the oil is necessarily excluded

as an explanation of the phenomenon. Two pounds of oil,
1331 having a specific gravity of .9, would in the aggregate have a buoyant effort of two-tenths of a pound. This proportion of oil, recommended in the patent in suit as "suitable and economical" (p. 1, l. 101), has been but very slightly departed from in the extensive use of the invention wherein $10,000,000 worth of valuable material has been recovered, mostly from dumps otherwise worthless. In Australia great quantities of concentrates were recovered with oleic acid at about this proportion, two pounds to the long ton of ore. In all of the extensive use of the invention, with various ores and various oils, the largest amount of oil that has been used has been four pounds to the long ton of ore, .179%, the smallest amount one pound to the long ton of ore, .045%. In the process, this minute quantity of oil, agitated with a long ton of ore and four long tons of water (11,200 lbs. in all), disappears from sight and sense. Its presence upon the concentrates can only be ascertained by chemical examination. The concentrates may be freely tabled or vanned without removal of the attenuated trace of oil which only chemical examination demonstrates to be present upon the concentrates. It is a fact proved in the evidence and not denied, that in the daily practice of the process at the Saxbergets Mine in Sweden, wherein the amount of oil used is the maximum of four pounds to the long ton of ore, the concentrates are passed through magnetic separators and then over the well known water treatment
1332 tables to separate the lead and zinc sulphides without removal of the oil (Rec., pp. 390, 391). This highly advantageous feature of the process of the patent in suit was not fully appreciated by the patentees when they diligently took out their patent, but surely it is not a valid criticism of a patent for a highly valuable invention that the patentees did not know and describe every advantage of their invention.

The most important document in the history of the invention is the report made by the metallurgist, Mr. Higgins, of the work that he did under the directions and instructions of the inventors, as a result of which the discovery was made. This report was made March 16, 1905 (Rec., pp. 895-898). It may be noted here that this was after two and a half years of research and experiment in the laboratory with the Cattermole process. Details of the experiments are given in a list (Rec., p. 896). With the oil at 3% on the ore, there was "very little float." Following this down the list, we come to oil at .32% "float vastly increased," and again, oil .1% with the same comment, and near the foot of this list, oil .02% (erroneously .002%), "little worse." Thus suddenly a quite surprising result was obtained with the conditions that had been assembled. There was a vast increase of float when the oil proportion was reduced to .32% and this was maintained or increased at .1% and was little worse at .02%. The experimenter sums up the results in his report as follows:

1333 "The effect of diminishing the percentage of oleic acid is to alter the type of oiling; the higher percentages producing granules and the lower ones froth" (Rec., p. 895).

Mr. Higgins also testified as a witness for the defendant-appellant as to these tests, and said:

"The quantity of floating material increased rapidly when the oil was reduced below a certain point, this certain point being .62% of the oleic acid on the ore" (Rec., p. 356).

Here, at a certain point in the line of experiments plainly appeared a new result, which is totally inexplicable on the theory of being a mere matter of degree, and is totally unaccountable except on the theory that a new mode of operation had been evolved and a new result attained, which it would be folly to attempt to define or characterize as mere economy in oil, in view of the fact that at least $10,000,000 worth of metal had been extracted by it that would otherwise have been wasted. Somewhere along the line of these experiments, when the quantity of oil had been reduced below .62% and under the conditions of the experiments, the Rubicon was crossed, the unpredictable and astonishing results began to appear, and the change in result became a change in kind evidencing and compelling the conclusion that there must have been a change of kind also in the mode of operation that was proceeding.

The theory of flotation by oil is excluded, first, because
1334 the quantity of oil had become so minute as to have a negligible effect upon the specific gravity of the metal, and, secondly, because the new result rapidly increased as the minute quantity of oil was made still more minute—just the contrary to that in an oil flotation process.

For the same reason, flotation by air bubbles in oil is excluded.

The true explanation seems to be that the violent beating in of air into a body of ore pulp, in which there is this minute quantity of oil, produces a froth that not only concentrates substantially all the metal and carries it to the surface, but that persists so that the metal does not sink again into the pulp and the froth carrying the metal can be separated from the pulp.

That there is a critical minute oil proportion for the effective production of the agitation froth, with each ore and oil or frothing agent, and that variation above and below this critical minute proportion of frothing agent impairs the efficiency of the operation, is abundantly proved in the evidence. We will first consider the testimony in behalf of defendant of defendant's foreman, Gibson, as a result of operating defendant's plant for seven months:

"Too much oil is indicated by a flat film on the surface of the water, the mineral forming globules and sinking" (Rec., p. 146).

1335 In other words the formation of a film instead of a froth on the surface of the pulp and the formation of granules which sink to the bottom result from an increase of oil above the critical proportion.

He also says:

"When too little oil is used there is no separation of the minerals and waste" (Rec., p. 146).

In other words, when the oil diminishes below the critical proportion, there is no concentration.

This is further proved by the testimony of Mr. Chapman, who installed and operated the agitation-froth process in Australia, Finland, Sweden and South Wales, as follows:

"110 Q. What has been your experience when, in using the agitation-froth process on a commercial scale, with a normal and proper consumption of one and a half pounds of oil per ton of ore, this procedure has been varied by increasing the oil feed to two and a half pounds per ton of ore?

"A. The mineral froth being produced on the spitz boxes loses at once some of its natural color and lustre and becomes dull in appearance. The quantity of froth being recovered on No. 1 box is considerably lessened. The froth on No. 2 spitz is slightly increased and the same with No. 3 box. The tailings on examination immediately show increased losses of sulphide mineral. These losses take the form of well oiled agglomerations.

"111 Q. And what has been your experience when the
1336 normal and proper feed of one and a half pounds of oil per ton of ore has been diminished to half a pound of oil per ton of ore?

"A. The froth being recovered immediately diminishes in quantity and the color shows the presence of slime gangue. The supporting liquor of the spitz box immediately changes in appearance and shows the natural color of the ore slimes. The tailings become very dirty and show no sign of what we know as a good 'clean-up.' In fact the whole treatment suffers and unless the oil feed is restored to its normal condition a serious drop in recovery takes place with the production of a lower grade concentrate" (Rec., pp. 393, 394).

This is the testimony of practical men from observation of the practical work of this truly wonderful process which is without doubt one of the greatest inventions in the metallurgical art.

Another remarkable characteristic of the agitation froth process is that the critical oil proportion bears no relation to the richness of the ore—the proportion of metalliferous mineral to be concentrated. In the Braden mines, Chile, 3% copper or 4½% mineral content, the maximum quantity of four pounds of oil to the long ton of ore is used (Rec., p. 394). At Broken Hill, Australia, with a rich ore, 50% mineral content, in present operations on ore from the mines, the minimum oil quantity is used, from .9 to 1.3 pounds per long ton of ore (Rec., p. 499). In this respect the agitation froth process is strikingly different from all prior processes, wherein
1337 the amount of metalliferous mineral to be lifted determined the oil proportion, as in Elmore and Froment, and even from Cattermole, wherein the amount of metalliferous mineral to be coated and made adhesive determined the amount of oil required. All of these facts clearly show that in the agitation froth process there is an operation new in kind which produces a result new in kind.

Other Adjudications. Reference was made in appellees' brief to the decision of the British House of Lords in the case of British Ore Concentration Company, Ltd., v. Minerals Separation, Ltd., 28 Reports Pat. Case, 33, wherein it was held that the agitation froth

process in issue in the suit at bar was wholly distinct from the Elmore oil buoyancy flotation process. Since the argument in the case at bar there has been a further decision by the Law Lords of England, which will be of interest to this Court, and copies of which are filed with this petition. It may be noted that the first decision, in the House of Lords case, was rendered by five Law Lords, Ex-Lord Chancellor Loreburn, Ex-Lord Chancellor Halebury, Lord Ashbourne, Lord Atkinson and Lord Shaw. The second decision, that of the Privy Council, was rendered by Lord Haldane, the Lord Chancellor, and Lords Dunedin, Parker, Sumner and Parmoor. There was a substantial unanimity of views of all ten Law Lords.

The Privy Council judgment, rendered March 6, 1914,
1338 was in a suit wherein the owners of the Elmore patents were plaintiffs and the Sulphide Corporation, Limited, licensees of the Appellee, Minerals Separation, Limited, were defendants. It appears in the record herein that the Sulphide Corporation, as such licensee, uses the process of the patent in suit. Mr. Francis A. Keating, a director of that company, testifies to profits therefrom of more than $3,000,000 (Rec., p. 496). Attention is particularly called to page 415 in this judgment and to the conclusions there stated, that the respondents, the Sulphide Corporation, Ltd., do not either directly or indirectly use the invention claimed in the Elmore patent, "but a process essentially distinct," and to the reasons given by the Law Lords for that conclusion, and especially the statement that the Law Lords accept the evidence that "the small quantity of oil introduced in the defendant's process" does not necessarily perform "any other function than permanency in the froth and extremely minute emulsion." Your Honors will remember that the agitation froth, as properly produced by Appellees and exhibited to the Court, was composed of minute air bubbles armored with metal particles, and that it remained unchanged for two days after production, while the evidence abundantly shows that the persistency of this froth is so great that the scientific witnesses have been tempted to call it a permanent froth.

The above noted decision of the British Privy Council, rendered
since the argument of the case at bar and which for that
1339 reason could not have been called to the attention of this Court, is in substance and effect, though not in terms, an adjudication that the patented process of Sulman, Picard and Ballot is an invention of great merit and required the exercise of the inventive faculty for its production. It goes without saying that these views of the English House of Lords, announced and concurred in by ten of the most eminent judges in England, are at variance with the views announced by this Honorable Court in the case at bar. Under these circumstances we submit that it would be a graceful act on the part of this Court to grant a rehearing for the purpose of considering the views advanced by the British court of last resort and of comparing those views critically with those advanced by this Court, to see whether or not this Court may not have inadvertently done an injustice to the appellees. Of course, we do not contend that the decision of the British court has the same effect

as that of the American courts, but we do say that by virtue of international comity existing between the courts of last resort of the two great English speaking nations of the world, it would not be out of place for this Court to grant a rehearing for the purpose of re-examining the questions at issue between the parties here.

We would also respectfully suggest in view of the apparent conflict between this Honorable Court and the highest Court of Great Britain that on a rehearing this Honorable Court, if it should after a reargument remain of the same opinion as it heretofore expressed, would have the opportunity of giving the opinion in such form that when cited in other countries in opposition to that of the highest Court of Great Britain, it would carry the weight which the opinion of this Honorable Court is entitled to carry in any jurisdiction.

We also feel that the Court's decision was influenced by a mistake of fact caused by the laboratory demonstration- made by appellant's counsel in open court at the oral argument. Those demon-
1340 strations were claimed by appellant's counsel to be representative of the prior art; but we earnestly contend that they were not demonstrations of the prior art, nor were they representative of any process shown in the prior art. They are wholly different from anything disclosed in the prior art. Apparently these laboratory demonstrations had much weight with the Court, and, partially at least, influenced the decision. If, therefore, they were not demonstrations of anything shown in the prior art, then manifestly the decision of this Court was influenced by a mistake of fact, and a rehearing ought to be granted.

Counsel for appellees-petitioners are profoundly convinced that the Court has misapprehended the real facts in the case and that a rehearing would work to ends of justice.

Respectfully submitted.

HENRY D. WILLIAMS,
JOHN H. MILLER,
WM. HOUSTON KENYON,
ODELL W. McCONNELL,
Counsel for Appellees-Petitioners.

I hereby certify that I have examined the foregoing petition and that in my opinion the petition is well founded; that the case is one in which the prayer of the petitioners should be
1341 & 1342 granted by this Court, and that the petition is filed in good faith and not for the purpose of delay.

JOHN H. MILLER,
Of Counsel for Appellees-Petitioners.

1343 [*Additional Authority in Support of Petition for Rehearing.*]

407.

In the Privy Council, Council Chamber, Whitehall, S. W., Friday, 6th March, 1914.

Present at the Hearing:

The Right Hon. The Lord Chancellor (Viscount Haldane of Cloan),
The Right Hon. Lord Dunedin,
The Right Hon. Lord Parker,
The Right Hon. Lord Summer, and
The Right Hon. Lord Parmoor.

Between THE ORE CONCENTRATION COMPANY (1905), LIMITED, and THE AUSTRALASIAN ORE CONCENTRATION SYNDICATE, LIMITED (Plaintiffs), Appellants,

and

THE SULPHIDE CORPORATION, LIMITED (Defendants), Respondents.

(On Appeal from the Supreme Court of New South Wales.)

[*Transcript of the Shorthand Notes of Marten, Meredith & Co., 8, New Court, Carey Street, London, W. C.*]

1344 Counsel for the Appellants: Mr. A. J. Walter, K. C., Mr. H. A. Colefax, K. C., and Mr. R. K. McDermott (Instructed by Messrs. Hays, Schmettau & Dunn).

Counsel for the Respondents: Mr. W. R. Bousfield, K. C., Mr. T. Terrell, K. C., and Mr. J. W. Gordon (Instructed by Messrs. Davidson & Morriss).

Judgment.

Lord Parmoor: This is an Appeal from the Judgment of Mr. Justice Simpson, Chief Judge in Equity of the Supreme Court of New South Wales, delivered on the 24th July, 1911. The action was brought to restrain the Respondents from infringing certain Letters Patent of New South Wales, No. 10,001 of 1900, granted to Francis Edward Elmore and No. 11,307 of 1901, granted to Alexander Stanley Elmore. So far as the action referred to Letters Patent No. 10,001 of 1900, granted to Francis Edward Elmore, it was abandoned at the trial, and this patent is now only material so far as it may affect the novelty of the invention claimed in the patent granted to A. S. Elmore. At the trial of the action the Appellants relied only on claim 1 of the Letters Patent No. 11,307 of 1901, and the Respondents did not attack the validity of any claims of the said Letters Patent other than claims 1 and 2. The hearing of the action lasted many days, and experts of great eminence gave evidence on both sides. In the result the action was dismissed.

This Appeal is brought by virtue of an Order of the Supreme Court of New South Wales granting leave to appeal and made on the 30th October, 1911.

1345 The Appeal was originally argued before the Board in October last and was subsequently re-argued.

The Chief Judge in Equity of the Supreme Court of New South Wales, in construing A. S. Elmore's patent, referred to the case of the British Ore Concentration Syndicate v. Minerals Separation, Limited, tried in this country and carried to the House of Lords (27 R. P. C., 33). He pointed out, however, in his Judgment that the case before him was in three material respects different from that tried in the English Courts:—

"(1) The New South Wales patent is a different document from "the English patent.

"(2) Everson's specification was before the English Courts; only "the claims in her specification are before this Court.

"(3) Criley and Everson's alleged prior publication (Exhibit 10) "was not pleaded in England and consequently was not before the "Court."

Their Lordships agree with the Chief Judge in Equity that these distinctions exist, and that they are material in character. Lord Atkinson in his opinion in the House of Lords states that there are only three constructions of which the English patent is reasonably susceptible. The first of these constructions, which was adopted by the majority of their Lordships, is that the only discovery alleged is the merit of acidulation, and that the process to which acid is to be applied is described in terms so wide that it covers any process, certainly any known process, of separating mineral substances by the selective action of oil in a mixture of ore, water, and

1346 oil. It was not argued by either of the experienced leading counsel before their Lordships that the New South Wales patent was susceptible of this construction without modification. The second of these constructions, which was not adopted, in the opinion of any noble Lord, is that:—

"The invention claimed consists in the addition of a relatively "small quantity of acid to a mixture of pulverized metallic ore, "water and oil of any consistency, irrespective of the proportion in "which the oil may be present relatively to the other ingredients, "provided only that the water and oil or water, oil and ore, which-"ever it may be, have been reduced to a freely flowing pulp."

Mr. Walter, the leading Counsel for the Appellants, did not argue that the New South Wales patent was directly susceptible of this construction, but urged their Lordships to accept a construction, which, when analyzed, is in some respects not dissimilar, since it connoted the free access of the oil to the metal in the mixture, a condition which would not be present unless there was a flowing pulp. The third of these constructions, which was adopted by Lord Atkinson and Lord Shaw, limited the invention claimed to cases in which the oil by "its own buoyancy floats the minute par-"ticles of the powdered ore to the surface." This limitation could not directly apply to the New South Wales patent, since the patentee

in terms includes the use of a selecting material of greater gravity than water and describes an apparatus by which separation can be effected without floating the minute metallic particles to
1347 the surface by the buoyancy of oil.

It was known many years prior to 1901 that oil, by its affinity to metal, operated to differentiate metal from gangue in a mixture of oil, water and ore. Haynes' patent, published in 1860, describes a method of separation of metal from gangue by the use of an agent containing fatty or oleaginous matter. This document, is, however, not more than an indication of the date at which attention was first directed to the affinity of oil for metals, and does not affect the novelty of the invention claimed. In 1886 the claims of the Everson patent were published in New South Wales. It is difficult to say that these claims, which directly refer to methods described in a specification, which was not published, and to which, for the purpose of this case, reference cannot be made, give any information of practical value. They do indicate that, for some unexplained reason and by some unexplained method, the mixing with a powdered ore of a fat or oil or a constituent thereof, and of an acid or soluble neutral, or acid salt, and water, will conduce to the breaking up of the mass, and the separation of metals or metallic minerals from rocky gangues, thus introducing a reference to the principle of acidulation. Whatever may be the extent and effect of this information, similar information is given in a more explicit form in an extract from the Engineering and Mining Journal in 1890.

To this extract the attention of their Lordships was directed in considerable detail. This extract describes a test of the "Criley "and Everson oil process" for the extraction of sulphurets
1348 from any ore by the use of oil, which the correspondent of the Journal had witnessed.

"The ore was crushed and passed through a 50 mesh sieve, weighed "and thoroughly mixed with black thick oil. To water heated to "near boiling was added enough sulphuric acid to give it a tartish "taste. This acidulated water was then mixed with the mass of oil "and ore. A thick scum of sulphurets rose to the surface and was "skimmed off, leaving the hitherto black ore as white as snow— "in fact, pure silica."

Although this test was published in the Journal many years ago, it is not suggested that the process ever came into practical use prior to the date of the A. S. Elmore patent. Judging by the experiments made, it was only effective in the case of an ore containing carbonates, and there was no proof that carbonates were found in all Australian ores. It was further urged on behalf of the Appellants that the directions as to the quantity of sulphuric acid were too vague, but the Respondents replied that the directions were in themselves sufficient, and in any case not more vague than the directions contained in the A. S. Elmore patent. Even if the test process is not to be discarded as a failure, it does no more than give information that if to a greased mixture of pulverized metal and rock you add boiling sulphuric acid in a sufficient quantity of water, in some

way a differentiation is effected as between the metal and the gangue. There is no indication that success depends upon the presence of carbonate in the ore, and in the absence of such indication, failure was at least as probable as success.

1349 The value of the Respondents' evidence on the meaning and teaching of this document was much vitiated owing to the form in which certain questions were put to their expert Mr. Blount. He was asked (Question 3164) to read the document with the knowledge which he would have in 1901. A question in this form is not admissible, and the objection taken by the Counsel for the Appellants at the time was well founded. It is a general canon of construction, applicable to all documents, that the document should be construed as if the Court had to construe it at the date of publication to the exclusion of information subsequently discovered. In patent cases the observance of this canon of construction has great importance. It is common, in such cases, to have a number of documents placed in evidence extending over a considerable period of time, each of which is relied on as disclosing relevant information prior to the date of the patent. If these documents require the assistance of experts to aid the Court in construction, the Court is deprived of the benefit of such assistance if the witness is asked to read the document not in reference to what was known at the date of publication, but to knowledge only acquired at some subsequent date.

The patent granted to Robson and Crowder in the year 1894 can be shortly dismissed. It describes a method of separation not based on acidulation, but to economize the use of water. The passage in the patent which was especially called to the attention of their Lordships, and which refers to the methods either of Criley and Everson or Everson does not add anything to the informa-

1350 tion to be deduced from the two documents to which reference has been made. The only remaining document to which the attention of their Lordships was directed is the patent of F. E. Elmore published in 1900. This patent does not refer to the use of acids during the process of separation. It describes an important method for separating the metallic from the rocky constituents of ores by first mixing water in considerable quantities with the pulverized ore, and then adding a more or less thick oil. The oil entraps the metallic constituents and retains them, while the mixture of water with the rocky constituents is allowed to subside. Subsequently the oil is separated from the metallic constituents by a centrifugal machine.

The result of the examination of the above documents is that at the date of the publication of the A. S. Elmore patent the principle of acidulation as a factor in the separation of metals or metallic particles from the earthy or rocky constituents in pulverized ores had been referred to in the claims of Everson, and in the test process of Criley and Everson. The Everson claims may be disregarded. The test process of Criley and Everson was found to be a failure, unless the ores contain carbonates, and in any event the only information given is that if to a greased mixture of pulverized metal and

rock you add boiling sulphuric acid in a sufficient quantity of water in some way a differentiation is effected as between the metal and the gangue. It was further known that there was an affinity between oil and metals or metallic particles, and that this affinity could be used in the separation of metals and metallic particles from earthy or rocky constituents by a practical and useful method
1351 as described in the patent of F. E. Elmore.

The next question is the construction of the patent. This is solely a matter for the Court, with the assistance of expert witnesses to explain technical words or technical processes. The patent, including the title, the body of the specification, and the claim or claims, is for the purpose of construction to be regarded as one document, and when construed it defines the nature and ambit of the invention claimed.

The patent is for an invention entitled "Improvements in the "process and apparatus for separating mineral substances by the "selective action of oil." It is noticeable that the expression "selective action of oil," on which much of the argument has turned, is used in the title as well as in the body of the specification and the claim. It is not an expression to which any definite technical scientific meaning is attached.

The patent commences with a narrative statement of the method by which the selective action of oil has been utilized to separate metals and metallic substances from gangue. This is said to be generally done by pulverizing the ore and suspending it in a considerable quantity of water, so as to make a freely flowing pulp, and then mingling it with oil, proferably heavy oil. The effect is that most of the metallic substances are entrapped in the oil, and when the mixture rests, the oil floating on the top is separated from the gangue which is run off with the water as tailings. In substance the method said to be generally adopted is the method of F. E. Elmore, though heavy oil is only preferably used. Unless the
1352 oil used has sufficient tenacity to retain the entrapped metallic particles, separation would not be effected. The oil is afterwards separated from the metallic substances usually by centrifugal action.

The patentee then sets out his invention. He states that in carrying on "this separating process," he has discovered that in some cases a slight acidulation greatly enhances the selective action of the oil. No scientific explanation is suggested or given, but the result and the utility of the result are not questioned. The enhanced selective action of the oil operates to give a better separation than when no acid is present. The words "selective action of the oil" have the same meaning in this passage as in the preceding narrative. To effect separation the oil must be adequate in quantity and of sufficient tenacity not only to entrap the oil but to hold and carry it until separation is effected.

No special directions are given or required for acidulation. A little acid may be added to the oil, such as oleic acid, or to the aqueous pulp, such as sulphuric acid, or the acid cuprous liquors, obtained in mine working. In either case the quantity is small,

and often need not exceed one five-hundredth part of the volume of oil or water employed in the operation, the quantity varying according to the character of the material treated.

The patentee includes in his process not only oil but other fluids with selective action, such as tar or varnish.

Tar is of greater gravity than water, so that, as the patentee explains in a subsequent part of his patent, in this case a sepa-
1353 ration does not depend on the floating or rafting principle, but would be carried out by means of the apparatus described in figure (3). If plumbago, elementary sulphur, or other similar substances are present the oil attaches itself and coats such particles, and the selective action of oil is not different from that in the case of metals or metallic substances.

Having described his main invention, the patentee describes two forms of apparatus for effecting separation.

It is not necessary to consider in any detail figures (1) and (2). The apparatus depends on the buoyancy of the oil and a separation is effected by floating the metallic ingredients in the oil over the lip of a weir, while the gangue subsides and issues through a pipe provided with a cork. The oil is subsequently separated from the metallic ingredients by a centrifugal machine.

The appellants place considerable importance on the second form of apparatus described in the patent and illustrated in figure (3). In this apparatus a thin stream of oil is thoroughly mixed with the pulp, and the oil "by its selective action coats or absorbs the me-" tallic particles, sulphides, tellurides, and the like." The whole mixture then flows over a weir and down an incline over a number of wave-like steps or baffles by which the stream of pulp and "oil globules" is thrown against an oiled apron continuously moving in the opposite direction. Separation is effected by the oiled surface of the apron taking up most of the oil globules and by also picking up from the pulp such particles of metallic substances as have escaped oil selection in the mixer. The patentee dis-
1354 tinctly draws attention to the fact that separation in this apparatus does not depend upon the buoyancy of the oil, and that consequently tar, heavy residuum oils, and other like substances of a greater gravity than water may be employed as the selective agent. The question arises whether the selective action of the oil or tar when the separation is effected by the second apparatus differs from the selective action of oil when the separation is effected in the first apparatus. The answer is in the negative. The "coating or absorbing" described in connection with the second apparatus is not different in character from the entrapping described in the first apparatus. The "oil globules" hold and carry the metallic particles and are taken up by the oiled surface of the apron which also picks up from the pulp such particles of metallic substances as have escaped selection by the oil in the mixer, that is to say, such particles as have not been coated and carried in the "oil globules." The separation of the oil from the minerals may be effected in a centrifugal machine in the manner described.

The first claim on which the contest arises is as follows: "In pro-

"cesses for separating minerals by the selective action of oil, the ad-
"dition of a small quantity of acid to the oil or water employed in
"the process, or to both substantially, as and for the purpose set
forth."

There is no claim for the general principle of acidulation in any process for separating minerals. No such construction was put forward on behalf of the Appellants. The claim is: "in processes
" for separating minerals by the selective action of oil." The
1355 first question to determine is the meaning of the words "the selective action of oil." They occur in the title, in the body of the specification, and in the claim, and should be construed in the same sense throughout, unless there is some special differentiation introduced by the context in which they occur. No such source of special differentiation was suggested in argument on behalf either of the Appellants or the Respondents. The Appellants contended that the expression "the selective action of oil" is referable only to conditions where the oil has a free choice between the two kinds of particles, selecting one and leaving the other, such conditions only prevailing in a freely flowing pulp. The Respondents did not seriously question this limitation, but denied that it was material at what stage in the process the selection took place, and that such selection could be made though in the first instance the whole mixture was greased. So far as this difference is of importance it only affects the issue of validity, since the Respondents in the alleged infringement undoubtedly use a watery pulp such as is used by the Appellants. The Respondents further contended that the expression "the selective action of oil" was referable only to conditions in which the oil is present in sufficient quantities to entrap or coat or absorb the metallic particles, and is of sufficient tenacity to carry these particles in the process of separation, whether by buoyancy or in the form of oil globules. Their Lordships are of opinion that this contention of the Respondents is well founded, and that the same considerations apply whether the process is carried out by the apparatus shown in figures (1) and (2), or
1356 by the apparatus shown in figure (3).

The remaining portion of claim 1 presents no difficulties in construction: "the addition of a small quantity of acid to the oil
"or water employed in the process, or to both substantially, as and
"for the purpose set forth." The words "substantially as set
"forth" refer to lines 35 to 40 on page 1 of the specification, and the words "for the purpose set forth" simply denote an acidulation whereby the selective action of the oil is enhanced. There are no special directions as to quantity, but none are necessary.

The invention claimed is, therefore, the enhancement of the action of oil, as a selective agent, by the addition of a small quantity of acid to the oil or water in any process of separation in which the oil is adequate in quantity and of sufficient tenacity to entrap or coat mineral particles in a watery pulp, and to hold or carry such particles until separation is effected. There is no limitation to the two forms of apparatus specially described in the specification.

The question whether the discovery claimed in the patent consti-

tutes invention, such as will support the validity of a patent grant, is a question of fact to be determined in each case upon all the relevant circumstances. In the present case there is no substantial difficulty. There is clearly no anticipation, nor was this case put forward in argument. The discovery of the patentee was at the date of the patent both novel and useful, resulting in a new process of commercial importance and value. If a discovery complies with these tests, there is invention sufficient to give validity to a
1357 patent grant, and it does not matter whether the discovery was the result of long research or of a sudden thought. The patentee gives no theory of the action on which his invention depends, and he is under no obligation to do so. It is said that the theory is not understood. In such a case prevision is not possible, and it is difficult to negative novelty unless the actual invention claimed has been either disclosed or used prior to the publication of the patent.

The last issue is that of infringement. Have the Respondents, either directly or indirectly, used the invention of the Appellants or any part thereof without their leave or authority first obtained, in the process which they employ for separating mineral substances from the earthy, or rocky constituents of ore? There is no suggestion of leave or authority. It becomes necessary therefore to ascertain what is the method in fact employed by the Respondents in the process alleged to be an infringement of the patent.

There is practically no controversy as to the main factors in the process used by the Respondents. In answer to interrogatories administered by the Appellants, the Respondents state that at relevant dates they did use a process in which pulverized ore and water are brought into contact with oleic acid; in which pulverized ore and water are mingled with oleic acid; in which oleic acid is mingled or mixed with pulverized ore and water; and further that they did use at relevant dates a process in which a mixture consisting of oil, water, and oleic acid was in the initial stage slightly acidulated; in which sulphuric acid was added to a mixture of ore, water, and oleic acid, and in which oleic acid was added to a mixture of ore, water,
1358 and sulphuric acid. The Respondents, however, alleged that their process could work with practical utility without any admixture of oil; but, whether this is so or not, oil was in fact used, and the issue of infringement must be decided on this basis. It appears moreover to be proved by experiments made by Mr. Ballantyne that the oil used by the Respondents plays an effective part in the success of their process. If the Respondents desire in the future to use a process without any admixture of oil they can do so, since the Appellants do not claim that in such a process their right would be infringed.

The real difficulty which their Lordships have to determine is whether the Respondents in the process of separation which they employ, entrap or coat and hold or carry the metallic particles in oil, using oil as the selective agent. The Respondents deny that they in any way use the Appellants' invention, and say that their process is essentially distinct, and that its successful operation depends on

the law of surface tension. It is not incumbent on the Respondents to explain the law on which the success of their process depends. The Chief Judge in Equity has not found it necessary to decide whether the true explanation of the Respondents' process is the law of surface tension, but states that he is inclined to think that the balance of evidence is in favor of the view of Professor Pollock. This view is very clearly expressed in an answer given by Professor Pollock to Question 5610: "I think that the main fact that underlies "the working of the Defendants' process is that water in the presence
" of air wets the gangue material but does not wet the metal-
1359 " lic particles. That combined with another fact which may
" be stated in this way, that liquids behave as if they were "contained in an elastic membrane which is always tending to con-"tract, gives the result that if a bubble of air rising through the "liquid meets a gangue particle the mutual forces are those of re-"pulsion, whereas if it meets a metallic particle the metallic particle "pierces the surface and the forces are such as to entrap the metallic "particles on the air side of the liquid air surface." Professor Pollock produced a drawing at the trial to illustrate his meaning, and much assistance was given to their Lordships by a drawing made and explained by the leading counsel for the Respondents. The attention of their Lordships was directed to many other relevant passages in the evidence of Professor Pollock, and to Rayleigh on Forces, Vol. 3, page 353. Whether Professor Pollock is right to the whole extent of the theory he expounds it is unnecessary for their Lordships to determine. The importance of Professor Pollock's evidence is that he shows that surface tension might account for the success of the Respondents' process, to this extent displacing any inference that the addition of an acid to a mixture of oil and watery pulp in a process of separation necessarily implies the use of the invention of the Appellants.

Apart from any question of theory, the Respondents use oil in their process under conditions which make it almost impossible to entrap or coat and hold the metallic particles by the selective agency
of oil. The Respondents use a thin oil at a temperature of
1360 120° Fahr., the quantity is minute, not more than 2 or 3 pounds to a ton of ore, or about 2 or 3 pints of oil to 10,000 pints of water; the resulting concentrate is practically free from oil and no mechanical contrivance to separate the oil from the metallic particles is required or used; the residue of the first concentration is further treated without any further addition of oil. There is no doubt a difference in the views of the respective experts whose standing and experience entitle them to great weight and authority; but in deciding between these views their Lordships accept the evidence of Professor Pollock to be found in Question 5780 and the following questions. This evidence may be summarized as follows: Professor Pollock is referred to his earlier evidence, and states that he does not think that the small quantity of oil introduced in the Defendants' process necessarily performs any other function than permanency in the froth and extremely minute emulsion. He allows that there may be oil in excess, and that some of the particles

may get oiled, but states that this is entirely and absolutely unessential. He does not however think that more than the necessary quantity of oil is introduced to effect concentration, but that having regard to the nature of the problem it is a matter of conjecture, and exact calculation is not possible. Finally, he reiterates his opinion that the Defendants' process can be accounted for without assuming selection of the metallic particles by oil. Applying this evidence, their Lordships find that the Respondents do not either directly or indirectly use the invention claimed by the Appellants, but a process essentially distinct, and that there is no infringement.

1361 This conclusion would dispose of the whole case, but their Lordships were invited to decide the construction of the Patents Act, 1903-1909, of the Commonwealth, in its bearing on the validity of the patent, if claim 2 of the patent was held to be invalid. It was argued on behalf of the Appellants that even if claim 2, contrary to their contention, was held to be invalid, the invalidity of this claim would not affect the validity of the patent so far as it relates to any valid claim. This would be so if the Commonwealth law applied, but in the opinion of their Lordships it does not apply. Section 6 of the Commonwealth Act enacts that that Act shall not affect any proceedings under any State Patent Act, nor any right or liability acquired or incurred before the commencement of the Commonwealth Act. The liability of a patentee to have his patent held invalid in the event of any claim being bad is a liability within the meaning of this saving section, and if claim 2 could not be maintained the whole patent would be invalid on this ground. Their Lordships, however, are of opinion that the invalidity of claim 2 has not been established and that the patentee has a valid grant to support the invention which he made and claimed.

In the result, their Lordships will humbly advise His Majesty to affirm the decision of the Chief Judge in Equity and to dismiss the Appeal.

The Appellants will pay the Respondents' costs of the Appeal.

Mr. Walter: Your Lordships are entitled to give us a certificate that the validity of the patent came in question. Your

1362 Lordships have declared the patent valid. Under Section 91 your Lordships can, in any proceeding, give a certificate that the validity of the patent came in question.

Lord Sumner: Did not you get your certificate below?

Mr. Walter: No. It is only that the validity came in question.

Lord Parmoor: Is there any objection?

Mr. Bousfield: No; and it is not a matter that I am entitled to be heard on, I think.

Lord Parmoor: I think we can do it.

Mr. Walter: If your Lordship pleases.

[Endorsed:] In the Privy Council. Council Chamber, Whitehall, S. W., 6th March, 1914. Present at the Hearing: The Rt. Hon. The Lord Chancellor (Viscount Haldane of Cloan), The Rt. Hon. Lord Dunedin, The Rt. Hon. Lord Parker, The Rt. Hon. Lord Sumner, and The Rt. Hon. Lord Parmoor. Between The Ore Con-

centration Company (1905), Limited, and The Australasian Ore Concentration Syndicate, Limited (Plaintiffs), Appellant-, and The Sulphide Corporation, Limited (Defendants), Respondents. Judgment. Davidson & Morriss, 40 & 42, Queen Victoria Street, London, E. C. No. 2346. United States Circuit Court of Appeals for the Ninth Circuit. Filed Jun- 1, 1914. F. D. Monckton, Clerk.

1363 At a Stated Term, to wit, the October Term, A. D. 1914, of the United States Circuit Court of Appeals for the Ninth Circuit, held in the court-room thereof, in the City and County of San Francisco, in the State of California, on Monday, the sixth day of July, in the year of our Lord one thousand nine hundred and fourteen.

Present: The Honorable William W. Morrow, Circuit Judge, Presiding; Honorable William C. Van Fleet, District Judge; Honorable Maurice T. Dooling, District Judge.

No. 2346.

JAMES M. HYDE, Appellant,
vs.
MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Appellees.

Order Denying Petition for a Rehearing and Staying Issuance of Mandate under Rule 32.

By direction of the Honorable William B. Gilbert and Erskine M. Ross, Circuit Judges, and Frank S. Dietrich, District Judge, before whom the cause was heard, it is ordered that the Petition filed June 1, 1914, on behalf of the appellees for a rehearing of the above-entitled cause be, and hereby is denied.

1364 Thereupon, on motion of Mr. John H. Miller, counsel for the appellees, and good cause therefor appearing, it is ordered that the issuance of the mandate under Rule 32 of this Court in the above-entitled cause be, and hereby is stayed for the period of sixty (60) days from date.

United States Circuit Court of Appeals for the Ninth Circuit.

No. 2346.

JAMES M. HYDE, Appellant,
vs.
MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Appellees.

Præcipe for Certified Transcript of Record, etc.

To the Clerk of said Court.

SIR: Please make and issue a certified printed Transcript of the record and nine (9) uncertified printed copies thereof, for use on an application to be made to the Supreme Court of the United States for the issuance of a writ of certiorari under Section 240 of the Judicial Code, in the above-entitled cause, the said Transcript to consist of the following:

1. Copy of printed Transcript of Record on which the above-entitled cause was heard in said Circuit Court of Appeals, to which will be added a printed copy of the following entitled proceedings that were had and of the papers that were filed in the said
1365 Circuit Court of Appeals, viz:
2. Orders of submission of cause;
3. Order directing filing of opinion and entering of decree;
4. Opinion;
5. Decree;
6. Petition for a Rehearing;
7. Additional Authority Filed in Support of Petition for Rehearing;
8. Order, entered July 6, 1914, Denying Petition for Rehearing and Staying Issuance of Mandate Under Rule 32 for 60 days;
9. Præcipe for certified Transcript of Record, etc., and
10. Certificate of Clerk U. S. Circuit Court of Appeals to said Transcript.

JOHN H. MILLER,
Of Counsel for Appellee.

[Endorsed:] No. 2346. United States Circuit Court of Appeals for the Ninth Circuit. James M. Hyde vs. Minerals Separation, Limited, et al. Præcipe for Certified Transcript of Record, etc. Filed Jul- 7, 1914. F. D. Monckton, Clerk.

1366 United States Circuit Court of Appeals for the Ninth Circuit.

No. 2346.

JAMES M. HYDE, Appellant,
vs.
MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Appellees.

Certificate of Clerk U. S. Circuit Court of Appeals to Record Certified under Section 3 of Rule 37 of the Rules of the Supreme Court of the United States.

I, Frank D. Monckton, as Clerk of the United States Circuit Court of Appeals for the Ninth Circuit, do hereby certify the foregoing one thousand three hundred and sixty-five (1365) pages, numbered from and including one (1) to and including one thousand three hundred and sixty-five (1365), to be a true copy of the entire record of the above-entitled case in the said Circuit Court of Appeals, made pursuant to the præcipe of counsel for the appellees filed therefor on the seventh day of July, A. D. 1914, and certified under section 3 of Rule 37 of the Rules of the Supreme Court of the United States, as the originals thereof remain on file and appear of record in my office.

Attest my hand and the seal of the said the United States Circuit Court of Appeals for the Ninth Circuit, at the City of San Francisco, in the State of California, this fourteenth day of July, A. D. 1914.

[Seal United States Circuit Court of Appeals, Ninth Circuit.]

F. D. MONCKTON, *Clerk*.

1367 UNITED STATES OF AMERICA, *ss:*

[Seal of the Supreme Court of the United States.]

The President of the United States of America to the Honorable the Judges of the United States Circuit Court of Appeals for the Ninth Circuit, Greeting:

Being informed that there is now pending before you a suit in which James M. Hyde is appellant, and Minerals Separation, Limited, and Minerals Separation American Syndicate, Limited, are appellees, which suit was removed into the said Circuit Court of Appeals by virtue of an appeal from the District Court of the United States for the District of Montana, and we, being willing for certain reasons that the said cause and the record and proceedings therein should be certified by the said Circuit Court of Appeals and removed into the Supreme Court of the United States, do hereby com-
1368 mand you that you send without delay to the said Supreme Court, as aforesaid, the record and proceedings in said cause, so that the said Supreme Court may act thereon as of right and according to law ought to be done.

Witness the Honorable Edward D. White, Chief Justice of the United States, the third day of November, in the year of our Lord one thousand nine hundred and fourteen.

JAMES D. MAHER,
Clerk of the Supreme Court of the United States.

1369 [Endorsed:] File No. 24396. Supreme Court of the United States. No. 652, October Term, 1914. Minerals Separation, Ltd., et al. vs. James M. Hyde. Writ of Certiorari. Docketed. No. 2346. United States Circuit Court of Appeals for the Ninth Circuit. Filed Nov. 12, 1914. F. D. Monckton, Clerk U. S. Circuit Court of Appeals for the Ninth Circuit.

1370 United States Circuit Court of Appeals for the Ninth Circuit.

No. 2346.

JAMES M. HYDE, Appellant,
vs.
MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Appellees.

On Appeal from the United States District Court for the District of Montana.

Stipulation.

It is hereby stipulated by and between attorneys of record in the above-entitled cause that the transcript of record now on file in the Supreme Court of the United States in the case of James M. Hyde, Appellant, and Minerals Separation, Limited, and Minerals Separation American Syndicate, Limited, No. 653, October Term, 1914, of said Supreme Court, shall stand as the return of the Judges of the United States Circuit Court of Appeals for the Ninth Circuit to the Writ of Certiorari issued out of said Supreme Court on the third day of November, A. D. 1914.

SHERIDAN, WILKINSON & SCOTT,
WALTER A. SCOTT,
Attorneys for Appellant.
HENRY B. WILLIAMS,
Attorneys for Appellee.

[Endorsed:] Stipulation as to Return to Writ of Certiorari. Filed Nov. 14 1914. F. D. Monckton, Clerk.

1371 United States Circuit Court of Appeals for the Ninth Circuit.

No. 2346.

JAMES M. HYDE, Appellant,
vs.
MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Appellees.

Certificate of Clerk U. S. Circuit Court of Appeals to Stipulation as to Return to Writ of Certiorari from Supreme Court U. S.

I, Frank D. Monckton, as Clerk of the United States Circuit Court of Appeals for the Ninth Circuit, do hereby certify the next preceding page, to be a full, true, and correct copy of a "Stipulation as to Return to Writ of Certiorari," filed in the above-entitled cause on the 14th day of November, A. D. 1914, as the original thereof remains on file and of record in my office.

Attest my hand and the seal of the said the United States Circuit Court of Appeals for the Ninth Circuit, at the City of San Francisco, in the State of California, this sixteenth day of November, A. D. 1914.

[Seal United States Circuit Court of Appeals, Ninth Circuit.]

F. D. MONCKTON, *Clerk.*

1372 United States Circuit Court of Appeals for the Ninth Circuit.

No. 2346.

JAMES M. HYDE, Appellant,
vs.
MINERALS SEPARATION, LIMITED, and MINERALS SEPARATION AMERICAN SYNDICATE, LIMITED, Appellees.

Return to Writ of Certiorari.

By direction of the Honorable the Judges of the United States Circuit Court of Appeals for the Ninth Circuit, I, Frank D. Monckton, as Clerk of said Court, in obedience to the annexed writ of certiorari issued out of the Honorable the Supreme Court of the United States and addressed to the Honorable the Judges of the United States Circuit Court of Appeals for the Ninth Circuit, commanding them to send, without delay, to the said Supreme Court the record and proceedings in the above-entitled cause, do attach to the said Writ and send to the said Supreme Court a certified copy of a Stipulation, entered into by and between the attorneys of record, that the Transcript of Record now on file in said cause in the said Supreme Court shall stand as the Return to the said Writ of Certiorari, the

original of which stipulation was filed in my office on the 14th day of November, A. D. 1914.

In Testimony Whereof, I have hereunto set my hand and affixed the seal of the said the United States Circuit Court of Appeals for the Ninth Circuit, at the City of San Francisco, in the State of California, this 16th day of November, A. D. 1914.

[Seal United States Circuit Court of Appeals, Ninth Circuit.]

F. D. MONCKTON,
Clerk of the United States Circuit Court of Appeals for the Ninth Circuit.

1373 [Endorsed:] File No. 24,396. Supreme Court U. S., October term, 1914. Term No. 652. Minerals Separation, Ltd., et al., petitioners, vs. James M. Hyde. Writ of certiorari and return. Filed November 28, 1914.

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